Stuart Otteson

The Bolt Action

Volume I

THE BOLT ACTION

The Bolt Action

A DESIGN ANALYSIS

by Stuart Otteson

Volume I

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Stuart Otteson

To Noreen and Lori

Acknowledgments

In researching this book, I was looking for a lot of information of a type not normally included in catalogs and gun publications. To get it required a good deal of interviewing, plus, in some cases, a lot of digging through old company files. I wish to extend appreciation to the following individuals who helped make this research possible:

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Finally, the idea for this book would have gone nowhere without Ken Warner. When Ken—who was then editor of Gunfacts Magazine—reviewed the original manuscript in 1969, he was somehow able to find potential in it. From that point on, he not only provided the necessary direction and encouragement, but opened the right doors for me in the firearms industry. Looking back on things now, it is obvious how hopeless a project like this would be without that kind of help.

Foreword

This is Stuart Otteson's book. It is not a synthesis of other men's writing, but a reflection of a real exploration of original records, and the bolt-action rifles themselves. Where the original designer was available, Stu talked to him.

They don't make books that way very often, but Stu Otteson did. That's why I'm pleased to be associated with the book, and enormously gratified that my contribution and collaboration was genuine. We had some fine arguments, he and I.

The drawings herein exemplify the Otteson approach. You have never seen them before, except for two little ones. Stu did them all, working from the guns, not factory drawings, old blueprints, or catalogs. It is my firm belief that these drawings are correct; where other drawings differ from these, such other drawings are in error, or they depict a model variation. Further, I believe few draftsmen have so clearly and economically delineated firearms mechanisms.

The design facts collected and interpreted by Stu here are likewise his and he got them from the guns. Here and there you will find this book to be at odds with other books about such things as lock times and spring rates and cam angles. Again, I believe this book to be correct in these matters.

There is also considerable historical content here. Most of it is based on the record of patents, again personally researched by the author. For the modern actions, the historical recitation is based on the public record, and on the recollections and statements of the men who did the design work. There can be errors—minor ones—in such material, as any editor knows, but I don't think you'll find many.

Who is Stuart Otteson?

He is a working engineer who owns and operates a lot of bolt-action rifles. He's a groundhog shooter and sometimes a benchrest competitor. He has an urge to excel, which is why he decided to write a book.

It's been six or seven years since he got that idea. Over that period of time he has learned a whole new trade. About three of the rewrites were my idea. When he then started rewriting and again rewriting the whole thing because he didn't like the way it came out, I knew there was going to be a book.

And here it is. If you're interested in rifles, you'll profit from reading it.

Ken Warner

Introduction

The detailed inner workings of the bolt action remain unfamiliar to many shooters, despite its long history as a military and sporting arm. Exactly what distinguishes it as a breech mechanism? Other actions seat, lock, and fire the cartridge, and then extract and eject the empty case as does the bolt action.

One is tempted to conclude that it is the lockup, where rotation engages locking projections of the bolt and receiver. Yet, many other action types have also utilized the turning bolt. Examples include the gas-operated Garand M1, the straight-pull Canadian Ross, and the lever-action Model 88 Winchester.

What defines the bolt action is the unique combination of the turning bolt and an integral operating handle which allows the direct application of pressure in proportion to the situation. Thus, not only is great power available, but it is under the complete control of the shooter.

A 2 to 2½ inch knobbed handle gives the operator leverage to turn the bolt. This leverage is in turn multiplied by the internal cams. Since bolt-knob movement over a quarter-turn usually exceeds 3 inches, and seating and extracting a cartridge and cocking a firing unit involve only fractional displacements, considerable power is possible, without intermediate linkage. The internal helical-cut cams permit the bolt and firing unit to act as lead screws during part of the opening and closing cycles, producing small but powerful axial displacements.

A well-proportioned and finished bolt action operates with a smooth back-and-forth sweep of the bolt handle. The extraction and feed processes which result are not hidden deep within some complex housing, but may be observed and verified if desired. When the shooter feels the bolt handle bottom solid on turndown, there is then no question as to the rifle's status.

In some other types, as the shooter prepares to fire he may not have quite the same confidence. There is always the possibility that a cartridge wasn't stripped from the magazine, that lockup is not complete, or that the firing pin isn't fully set.

The strength, precision, and efficiency of the bolt action make it a fascinating study in engineering. Design and functioning is basic and simple, far easier to define in precise terms than most other repeating breech mechanisms, or even single-shot types, and therein lies its beauty.

The bolt action is long. The receiver threads deeply onto the barrel and holds within it the turning bolt to form a solid locking unit. While the length eliminates some trimness possible in other actions, it also serves to advantage. The long hollow bolt interior houses a straight-line firing mechanism. Most more compact designs offer less ideal firing units, without the same speed, efficiency, and power. The long receiver is also naturally shaped to store and feed cartridges, and its length and structure clamp solidly to a one-piece stock, effectively supporting the barrel in a cantilever manner.

The ability to handle high-intensity cartridges and function with certainty under adverse conditions quickly made the bolt action the dominant military rifle in that period between single-shot rifles and the present autoloading weapons. It easily outperformed all other repeating breech mechanisms in trials held by various nations before the turn of the century. It was superseded by automatic and semi-automatic types, but its derivations remain supreme for most sporting purposes. It will doubtless continue thus for the foreseeable future because of its practical superiority for all shooting that stresses accuracy and certainty.

The turning-bolt concept began with the Dreyse needle gun of 1838. From this developed several distinct types, the two principal ones surviving today in commercial form being the Mauser and the Mannlicher. To a certain extent, both may be considered to be of basic Mauser origin, since the Mannlicher system has many features derived from the early black-powder Mausers. The Mauser pattern is the more important and forms the basis for most current designs. Mauser features still widely applied include the one-piece bolt with front locking lugs, fixed-box magazine, and the cam system functioned by rotation of the bolt handle.

The bolt action is superior for sporting rifles today not only for these basic Mauser operating concepts, but equally for its status for seventy-five years or so as a principal military weapon throughout the world. As such, it received more engineering, underwent more testing and development, and was tried in more design forms than is usually possible with a pure sporting arm.

By World War I, however, military designers were through with the bolt action for practical purposes. It remained in military use, of course, through World War II and even much longer, but, with only a few exceptions like the French MAS bolt rifle of 1936, the military expended little further development effort. The same was true commercially, at least until a few years before World War II when Winchester developed its Model 70.

Two post-war commercial rifles revitalized evolution of the bolt action. In 1948, Remington introduced the 721/722 series with its cylindrical receiver and bracket recoil lug, fabricated bolt, and shrouded breech with internally mounted extractor and ejector. About ten years later, the Weatherby Mark V popularized the multiple-lug locking pattern, massive full-diameter bolt, and complete gasproofing system with shrouded bolt sleeve.

Many other designs have provided innovative concepts, as well as subtle design variations. For the main part, however, current bolt-action trends follow these landmark designs, usually with combinations of their features.

The actions in this book for the most part trace a heritage to the Mauser pattern. Some of the later ones, such as the Remington Model 788, however, have obviously moved pretty far in other directions.

A representative selection is examined, starting with several important military actions and their commercial derivations. The remainder of the text covers eight post-war designs. Many others could be included, with more appearing each year. Activity in bolt-action design, has, in fact, increased sharply in recent years. The type is not dying out.

This book considers the action, and not the barrels or stocks that accompany the factory-assembled units. The action is the heart or essence of the rifle, not simply because it holds the other parts together as a unit, but because it establishes the rifle's character and identity. The action endures. Stocks and barrels may come and go. Stocks and barrels and sights are interesting, but the action alone provides plenty of challenge for an analysis like this.

Each chapter here concludes with a summary of strong and weak points. For continuity, this is put into the context of building a modern scoped sporting rifle. Evaluation on a strict historical basis, of course, may have been more appropriate for the early actions. For example, the Arisaka doesn't convert to a very attractive sporter, but that doesn't alter its historical status as a sound military weapon. Certainly it is neither desirable nor profitable to alter all prewar arms to modern configurations, particularly those with significant potential collectors value, but this has been a common practice.

These individual evaluations are based only on a comparison with the best features of other bolt actions, and to achieve emphasis are limited to notably strong and weak features. As an example, lock time of the Winchester Model 70 is not listed in either column, because while it was considerably faster than earlier actions like the Mauser and Springfield, it is not faster than, or even as fast as, many of the more recent designs.

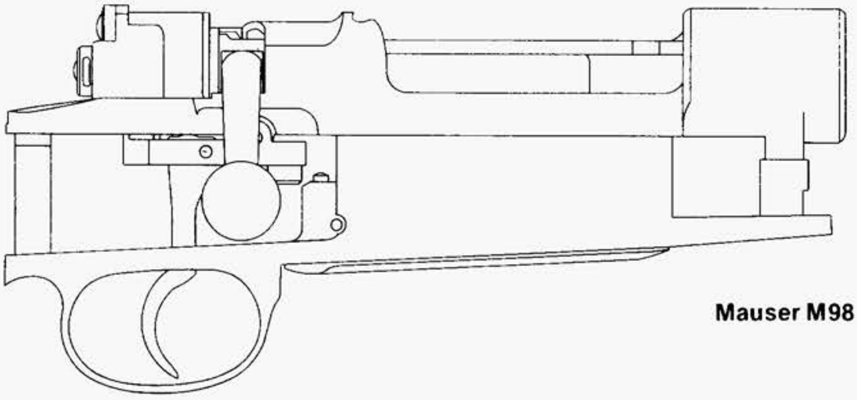
Obtaining some of the functional data presented here initially seemed a problem. Manufacturers are to varying degrees reluctant to release such information, and even if they weren't, the compilation would lack consistency. The only practical approach is to disassemble each action and make the necessary measurements and calculations directly. This was done. Available factory data was then used simply to verify the methods.

Conclusions are based in most cases on measurements from only one or two specimens of each action. Thus, manufacturing tolerances and the changes from time and wear are not accounted for. None of these, however, is important enough to compromise the observations.

THE
BOLT
ACTION

1

Mauser Model 98



Mauser M98

Paul Mauser (1838–1914) is easily the dominant figure in the development of the bolt-action rifle. The following briefly traces his work which led ultimately to the Model 1898, which we will call the M98:

In the mid-1860s, already possessing a substantial background in ordnance, Paul Mauser began working on an improved version of the Dreyse needle gun, the original bolt action and at the time the service rifle of the Prussian Army. He was unsuccessful in selling his work, however, and in 1867 Paul and Wilhelm Mauser entered into what turned out to be a short-lived contract by which they were sponsored and financed by Samuel Norris. In 1868, the Mauser-Norris rifle was patented (U.S. Patent 78,603) but still not adopted by any country.

In 1871, with Norris out of the picture, a much improved version of this rifle was adopted by Germany, and the Mauser organization was thus founded. This Model 1871 bore little resemblance to the later smokeless-powder Mauser bolt actions. It had an open bridge, front-mounted extraction cams, an external cocking piece, a separate bolt head, and rear locking. Still, it remained for many years the technical basis for Mauser rifles, while Paul Mauser's improvements in bolt-action design progressed at a rather slow pace.

Two important events occurred in the period of 1888–89. The first was adoption of smokeless powder. Perhaps equally important, Mauser suffered a by then unaccustomed setback when the German Rifle Testing Commission rejected his rifle.

Not long after losing the German contract, Mauser submitted a design for the Belgian Rifle Trials, again unsuccessfully. This design was a transition between the Model 1871 pattern and later patterns which ultimately led to the M98. It had a closed bridge with rear-mounted extraction cams, dual rear locking lugs, and the same heavy and clumsy external cocking piece as the Model 1871.

The year of 1889 was certainly pivotal for Mauser fortunes, and perhaps for bolt-action development in general. Mauser abandoned the Model 1871 pattern entirely, and in its place developed a remarkable series of new concepts.

The following U.S. Patents were all signed by Paul Mauser on September 2, 1889:

427,587 issued May 13, 1890 (ring extractor)
431,668 issued July 8, 1890 (combined bolt stop/ejector)
431,669 issued July 8, 1890 (T-slot extractor)
431,670 issued July 8, 1890 (dovetail extractor)
440,955 issued Nov. 18, 1890 (bolt sleeve)
449,352 issued March 31, 1891 (wing safety)

What evolved from the above activity was Mauser's first successful smokeless-powder rifle, the Model 1889 Belgian. The cocking piece and bolt sleeve were separated, giving faster and more positive ignition. The bolt was one piece, with front locking lugs. Finally, the rifle had a clip-fed box magazine, the cartridges in single column.

The Model 1889 marked the beginning of worldwide Mauser domination of military bolt-rifle design. Before this, there may have been a question as to whose ideas would ultimately prevail, but not after. Over the next six years Mauser steadily improved the Model 1889 pattern, keeping far ahead of his contemporaries: the nonrotary extractor in 1891, the lugged firing pin in 1892, the staggered-column fixed-box magazine in 1893, the three-position safety in 1894, and in 1895 the inner-collar breech, bolt-sleeve lock, and bolt-sleeve gas flange. By 1895, the design of what would become the M98 had thus taken shape.

The adoption of his design on April 5, 1898, by the German Army was certainly the high point of Mauser's long career. For the remaining years until his death in 1914, Paul Mauser continued in arms development, but almost exclusively in the field of autoloading weapons.

The M98 was superior to any bolt action before it. Its engineering and design were so correct that it remains even today the standard by which others are judged. Most later-developed bolt designs only refine this Mauser, making it the logical starting point for our study. A lot of patents are referenced here, yet they represent but a fraction of the total granted Paul Mauser. He was prolific, and in the U.S. alone was granted 83 patents related to arms design and manufacture.

Although of German design, the M98 has been made by several European countries, plus a few others like China and Mexico. At one time or another, it served throughout the world, and surplus actions originate from a wide variety of arsenals.

Countries like France, Britain, Italy, Russia, and the United States developed their own military bolt rifles, for obvious reasons, but none surpassed the M98 in design or performance. It survived them all, and is still going strong in commercial form, three-quarters of a century later.

We will begin analysis with the M98 breeching system. An effective breech involves two aspects: direct support of the cartridge against a primer or case-head failure, and control of gas escape if primary failure occurs.

Considering direct support first, the ideal arrangement would entirely encircle the case head with bolt, receiver, and barrel, leaving no brass unsupported. The practical need to feed, extract, and eject cartridges, however, makes this difficult.

Mauser's one-piece bolt can also be an obstacle in designing a high-efficiency breech. Systems with a separate, nonturning bolt head which slides straight up against the barrel during locking, as in the Mannlicher and the early Mauser designs, can more easily achieve a tight and perfect fit-up, with maximum support. Any protuberance necessary in the bolt-face rim can be matched exactly in the barrel. Mauser's M98 bolt head turns as it closes against the barrel, so such a match-up isn't possible. Each irregularity requires a quarter-turn path for clearance during locking and unlocking.

These irregularities from an ideally symmetrical pattern arise from the feed, extraction, and ejection cycles. Taking them one at a time, we can examine the influence of each:

Feeding: Part of the bolt rim is milled down flush with the bolt-face floor so cartridge rims slip under the extractor as they emerge from the magazine. A positive grip is achieved as cartridges leave the magazine and before being thrust into the chamber, thus avoiding any possibility of *double-loading*.

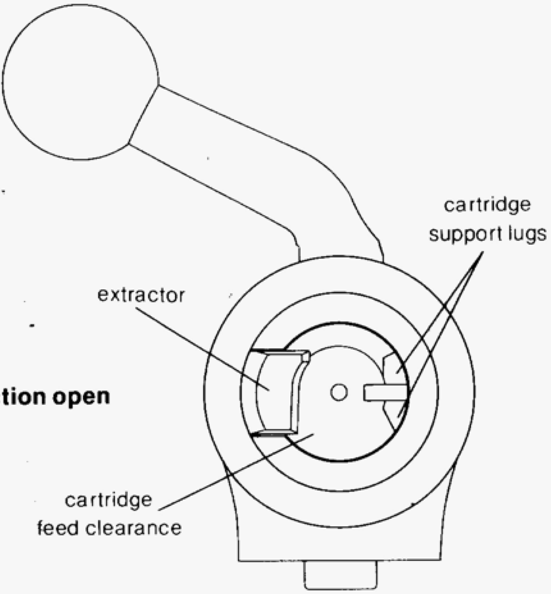
Today, double-loading is an almost forgotten design factor. It was considered important in the military bolt rifles, and involves a cartridge inadvertently jamming into one already in the chamber. This can occur where the bolt/extractor combination fails to grip the cartridge rim until the bolt is locked. In this type of setup, found in most current bolt designs, if the bolt is withdrawn before fully closed, the just-fed cartridge is left stranded in the chamber to jam the next cartridge stripped from the magazine.

Extraction: Attaining a good grip to pull the expanded case from the chamber has always been a basic roadblock to a perfect breeching layout. The external, collar-mounted Mauser extractor is locked from turning by the right raceway. Thus most of the bolt rim left after cutting away the feed clearance is milled down to cartridge-rim height to clear a path for the extractor claw. Only a small segment in front of the left locking lug is left at full height, for cartridge support during extraction.

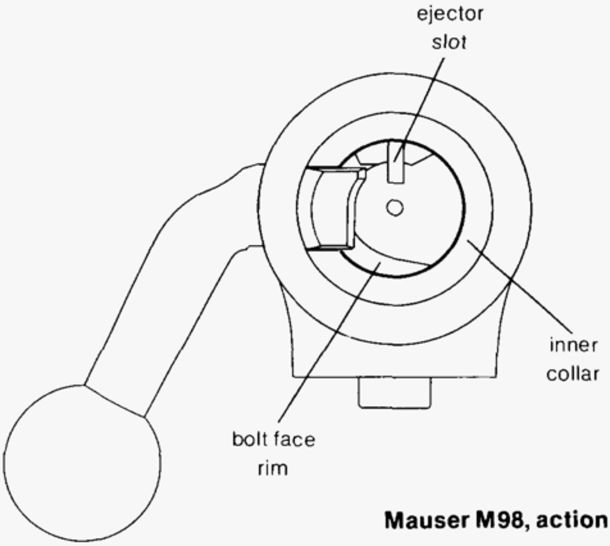
Ejection: The M98's receiver-mounted ejector blade slices into the bolt head to get at the cartridge base. The .08-in.-wide access slot penetrates both the left locking lug and the bolt face.

What this all adds up to is shown by the accompanying drawings of the bolt side of the breech in the open and closed positions. The barrel side is faced off square and seats against a collar machined inside the receiver ring and located .105 in. forward of the bolt face. (This collar is examined in detail later.) It fits up close to the small segment of rim remaining ahead of the left locking lug, but to nothing else on the bolt head.

Only about 30% of the case head protruding from the chamber is shrouded or encircled by the M98 bolt-head rim. This sounds pretty inefficient, particularly considering that newer systems like the latest Winchester and Remington types encircle a much greater percentage.



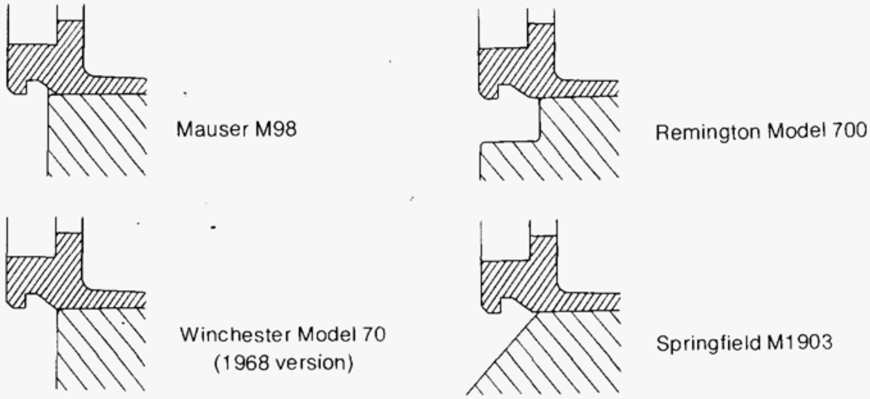
Mauser M98, action open



Mauser M98, action locked

On the positive side, however, the cartridge seats deep in the M98 chamber, all but the last .105 in. (This is the correct inch-system figure, despite the fact that the 2.8mm figure listed in Mauser catalogs converts to .110 in.) This seating depth in itself, regardless of encirclement detail, makes the Mauser strong. Most later and supposedly more advanced systems with their full and deep counterbored bolt heads also leave the cartridge head exposed .025 to .050 in. more from the chamber mouth than does the M98. This is not criticism of modern breeching techniques, which can be quite effective, but puts things in perspective. The Mauser breech was a carefully engineered system, particularly considering the emphasis required on feed, extraction, and ejection in designing for military use.

Breeching systems, cartridge protrusion

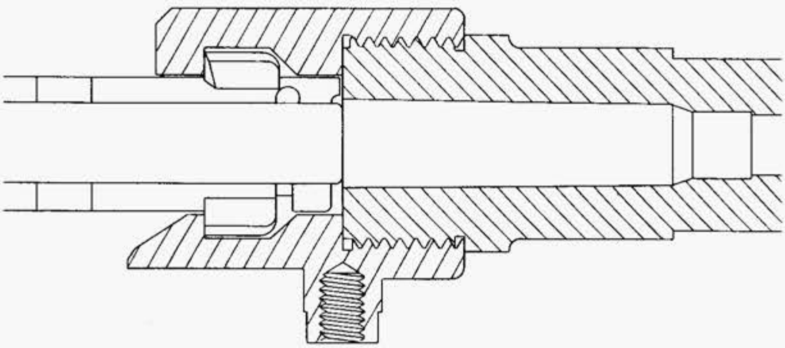

Mauser M98

Remington Model 700

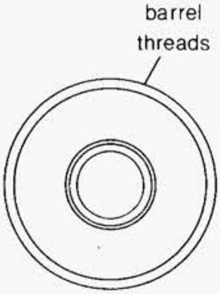
Winchester Model 70
(1968 version)

Springfield M1903

The second breech function, that of blocking gas escape, involves the real key to Mauser's breeching theories, the *inner collar* (U.S. Patent 579,994 issued April 6, 1897). The M98 locking lugs are set back and a heavy integral collar within the receiver ring closely encircles and shrouds the protruding bolt head. It is interesting to note at this point that this Mauser inner-collar breech and the later *counterbore* type as applied to the Arisaka, Remington, Weatherby, and so on, where the bolt head recesses into a close-fitting counterbore in the barrel, are to an extent the same basic idea. The steel ring encircling the bolt nose is simply built into the receiver in the Mauser and is part of the barrel in the others.



Mauser M98, standard breech



The M98 collar is slotted for the externally mounted extractor, but this doesn't cancel its value as a gas barrier, since the slot is in line with the ejection port. The function of the inner collar does suffer seriously when a *mirror* cut is broached into its left side, as in many modern commercial Mauser takeoffs such as the F.N., to simplify production. It then is neither an effective gas block nor structural reinforcement.

The original and genuine Mauser system, however, is effective and is so thorough, in fact, that even gas escape through the ejector slot is blocked by a small shoulder on the locking lug which bears against the upper receiver seat. Mauser carefully explained the gas-block function of this tiny shoulder in U.S. Patent 579,994. Yet, as with many other firearms features through the years, other interesting theories seem to evolve on their own. According to an article several years ago on the M98, this shoulder was left in the ejector slot as a form of sabotage by the satellite countries during World War II.

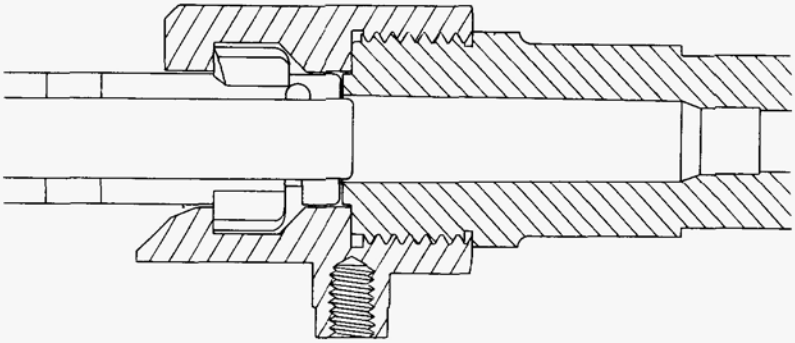
The inner collar also acts as the barrel stop, facilitating barrel fitting, which has proved a great advantage over the years, and as a structural reinforcement for the receiver ring. To avoid creating feeding jams, the collar's rear face is angled forward, presenting a funnel to incoming cartridges.

An interesting variation of the Mauser breech was developed in 1897, although not applied until some years later. The bolt rim is cut down to case-rim height all around, eliminating the support ridge and depending entirely on the .05-in.-high rim to position and hold cartridges during feed and ejection. The barrel mouth is brought back close against this rim by means of a .05-in.-high lip. Since the inner collar dimensions remain unchanged, breech gap ends up to be less than .010 in. A close-fitting slot in the right side of this barrel lip accommodates the protruding, but nonrotating, extractor claw.

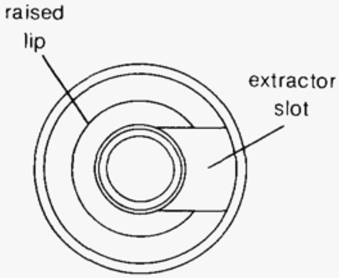
D.R.G.M. 89,815 issued Feb. 7, 1898, covers this breech. This is a document called a *Gebrauchsmuster* or utility model, issued where the level of invention required for a German Patent is not met. The Mauser features covered in this way generally do not have U.S. Patents, since by the late 1800s the U.S. no longer had a two-level patent system.

This raised-lip breech provides a cartridge-head shroud superior to that possible in the standard Mauser—in fact, one of exceptional strength which certainly rivals many more recent commercial designs. It is interesting to consider that had Mauser also been able to eliminate the feed clearance and ejector slot on the bolt head, he would have created a turnbolt breech of a strength probably unequaled even today, since it would both deeply seat and efficiently shroud the cartridge head. But that is only speculation, and in any event even the omission of the cartridge-support prong from the bolt head was considered to seriously jeopardize the M98's reliability of feed and ejection. Since sure functioning was paramount in a military weapon, the raised-lip breech saw only limited application.

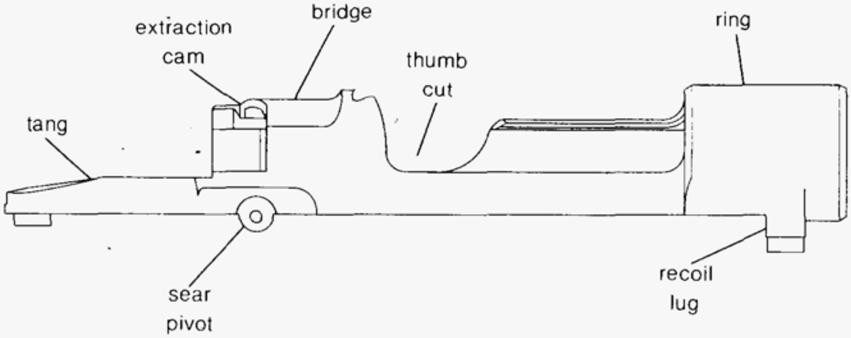
We have gone into an uncommon degree of detail in describing Mauser's breeching concepts, as they form a starting point for evaluating later systems. The breech has probably received more attention than any other single problem of turnbolt-action design. Because several considerations like strength, feeding, extraction, and ejection apply, an interesting variety of approaches have evolved.

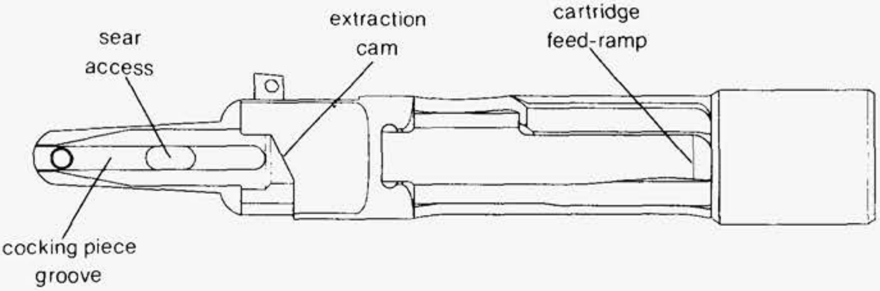


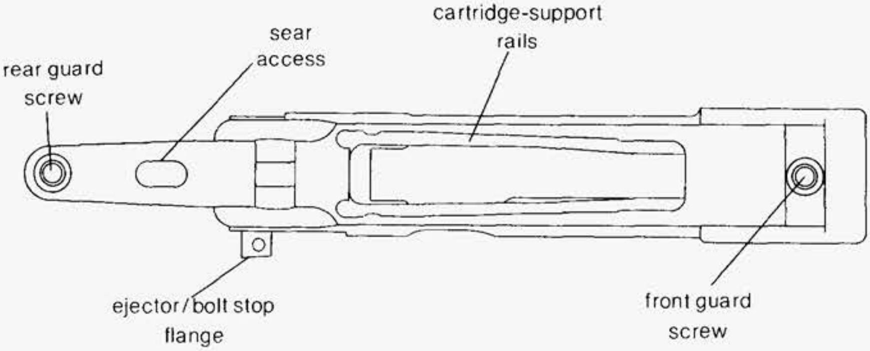
Mauser M98, raised-lip breech


raised lip
extractor slot

The M98 receiver is a carbon-steel forging. Commonly referred to as a *siderail* type, it has a flat bottom, integral recoil lug, two relatively flat siderails for a midsection, and a closed bridge. The left siderail is cut out to form a deep thumb clearance just forward of the bridge. The primary function of this notch is to aid clip charging of the magazine, but it also creates a gas-release point for the left raceway (D.R.G.M. 56,068 issued Aug. 9, 1895). When clip charging is not a factor, the desirability of this notch becomes suspect, since it does seriously weaken the receiver midsection. Thus it has not been carried over in present-day commercial Mausers.


extraction cam
bridge
ring
thumb cut
tang
sear pivot
recoil lug


sear
access
extraction
cam
cartridge
feed-ramp
cocking piece
groove


rear guard
screw
sear
access
cartridge-support
rails
ejector/bolt stop
flange
front guard
screw

Besides being the main structural member of the action, the receiver is the key part of the entire rifle, tying barrel, stock, and action into a solid working unit. The rigidity of the barrel joint depends on the wall thickness and the threading within the receiver ring. This is covered in the Summary, listing both the thread dimensions and the receiver diameter.

The M98 has a larger-diameter receiver ring than previous Mausers, due primarily to the big external extractor which requires a deeper right raceway. When this extractor was first used, Mauser continued with his original 1.3-in.-diameter receiver ring. As a result, in going from the Model 1891 to the Model 1893, wall thickness on the right side was reduced almost in half, from about .16 in. to .09 in. By increasing ring diameter to a little better than 1.4 in. in the M98, this section over the right raceway was brought back close to its original thickness.

How the receiver is patterned underneath controls the union between the action and the stock. Here two principal aspects apply—recoil factors and bedding. By current practice, recoil strength depends purely on the size and location of the recoil lug, which in the Mauser lies under the receiver ring. These dimensions control how much wood can absorb the impact of recoil. Historically, however, it should be noted that many years ago bolt actions of the Mauser type were bedded to distribute recoil also to the magazine box and the front and rear guard screw bushings.

The M98 recoil lug is shallow, giving only a .24 sq. in. bearing face. Separation from the magazine is less than 1 in. This combination does not really allow enough supporting wood to guarantee against splitting or setting back. Thus a steel cross bolt and recoil shoulder is used in the military Mauser stock, increasing the amount of wood that bears the shock. Commercial Mausers are also usually reinforced.

The M98 receiver beds on the flat underside, principally behind the recoil lug and at the rear tang. The front surface has about 1 sq. in. area. This is relatively small in comparison with most later bolt actions, and the Mauser is, in fact, not noted for maintaining a solid bedding in the stock.

Vertical guard screws thread into the recoil lug and tang. Both are bushed to prevent springing the receiver or floorplate. Nevertheless, a long slender tang and the deeply notched left rail leave the Mauser receiver weak and easily bent by guard-screw tension if support contact in the wood is imperfect.

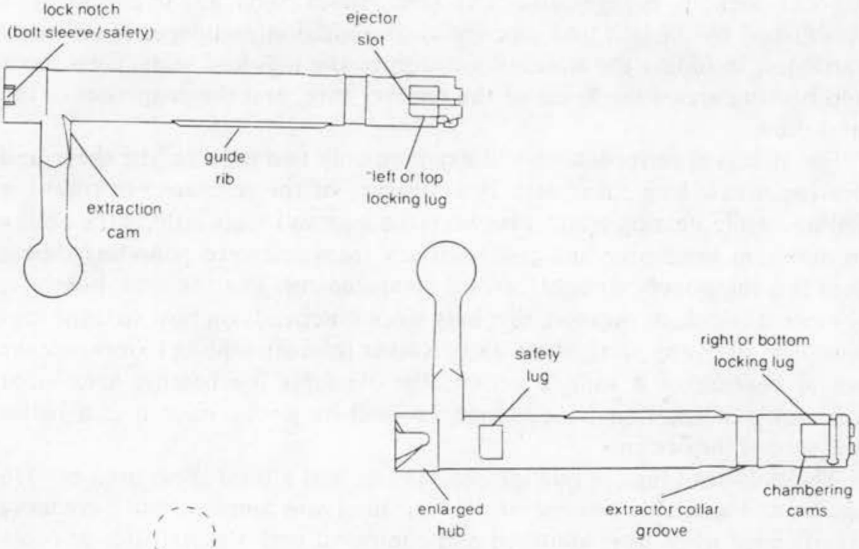
An interesting feature is the unique means built into the M98 receiver for seating the barrel. Contact is at the inner collar, rather than at the receiver ring proper.

This system permits closer control of cartridge-head protrusion. When the barrel shoulders on the receiver ring proper, as is the more common practice, three dimensions combine to affect protrusion: in the receiver, the distance from locking seat to receiver-ring face; on the barrel, from chamber mouth to shoulder; on the bolt, from locking lug to bolt face. By seating the barrel against the inner collar, Mauser eliminated one of the three tolerances, that on the barrel. The face of the inner collar forms a common reference.

Equally important, cartridge-head protrusion is permanently built into the action, eliminating the possibility of error when rebarreling. The process is uniquely simple and foolproof, with the barrel faced off square and no worry about extractor cuts, funnel contours, counterbores, critical shoulder locations, and the like.

The bolt, including the handle, starts as a one-piece carbon-steel drop forging. At the rear, it is drilled out for the firing-pin assembly, and on the rear rim are cut the cocking-cam notch and a small round-bottomed notch for the bolt sleeve and safety locks. A guide rib on the side cooperates with a slot in the bridge to help steady bolt travel, particularly on closing when the left locking lug passes under the thumb cut.

Dual-opposed locking lugs on the bolt head turn 90° to vertical to lock into the receiver ring and contain cartridge back thrust. Approximately 60° involve initial bolt play and the camming effort, leaving the final 30° for


lock notch
(bolt sleeve/safety)
ejector
slot
guide
rib
left or top
locking lug
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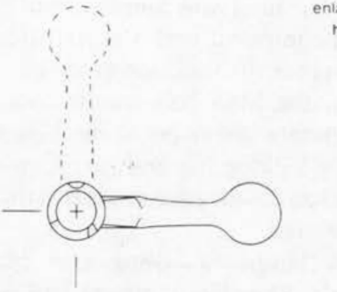
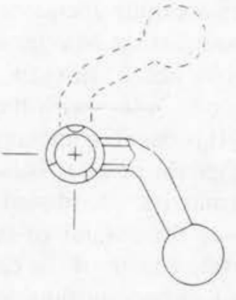
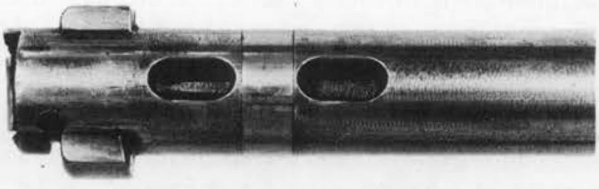


Mauser M98, bolt-handle profile (straight shank version)



Mauser M98, bolt-handle profile (bent down version)



Two large oblong ports in the walls of the M98 bolt dump escaping gas into the left lug raceway.

lug-seat locking engagement. The strength of such an arrangement is established by the bolt and receiver in combination and depends on many variables, including the size and location of the lugs and seats, their shear and bearing areas, thickness of the receiver ring, and the properties of the steel used.

For practical purposes we will examine only two aspects, the shear and bearing areas. Lug shear area is a measure of the resistance to total lug failure, while bearing contact between the lugs and seats reflects the ability to maintain headspace and resist setback from rearward pounding. Shear area is a reasonably straightforward measurement. Bearing area, however, is more difficult to measure precisely since it depends on how well the lugs and seats fit in any particular action. Rather than attempting to measure the actual bearing of a sample action, the *available* lug bearing area—that achievable if the lugs were lapped in—will be given, since it is a better measure of the design.

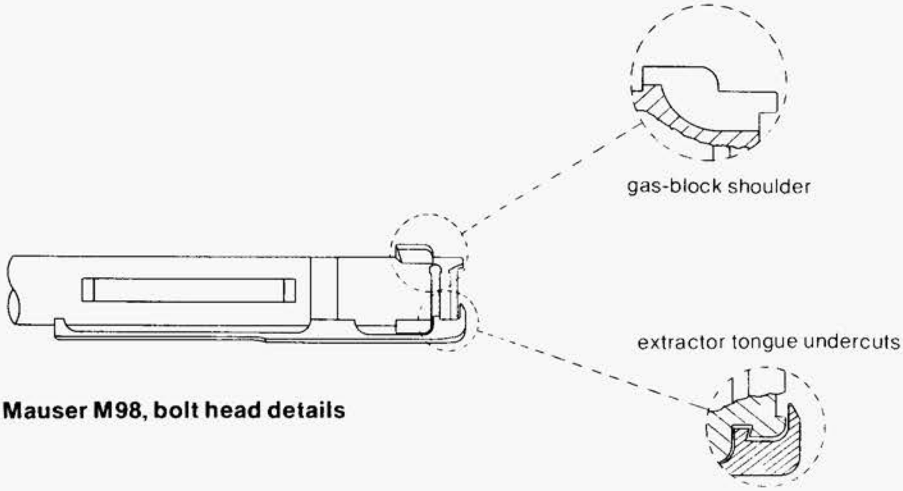
The bolt-head lugs in our sample Mauser had a total shear area of .316 sq. in. and available bearing of .054 sq. in. These numbers will have more significance when later analyzed and compared with the statistics of other designs. They are quite adequate values for the function involved.

Unlike some earlier Mauser rifles, the M98 bolt-handle root does not enter a receiver notch. Instead, a separate safety lug is machined near the rear of the bolt, in line with the right locking lug and just forward of the bolt handle. It is only for backup and has a clearance of several thousandths of an inch when the primary lugs are seated.

A long, massive, hardened and tempered spring-steel extractor is mounted along the outside of the bolt. The claw is strong and wide, gripping almost one-fourth of the case rim. Its shape also holds the cartridge up once engaged to prevent double-loading jams, thus accomplishing a function for which Mauser had previously developed special bolt-face plunger arrangements (U.S. Patent 476, 290 issued June 7, 1892).

A collar, affixed to the underside by a dovetail joint, holds the extractor inward, while allowing it to rotate freely. The extractor body is given a slight bow after machining so that spring tension holds it tight against the bolt.

The right raceway locks the extractor from turning as the bolt opens, permitting a smooth and efficient extraction. The claw doesn't rub or cut the cartridge rim during bolt lift, and extraction force acts as a straight pull. A tongue working in a narrow groove just forward of the locking lugs anchors the extractor axially. Both the tongue and groove are undercut so that resistance draws the extractor claw inward to prevent slipping off a stuck case.



Mauser M98, bolt head details

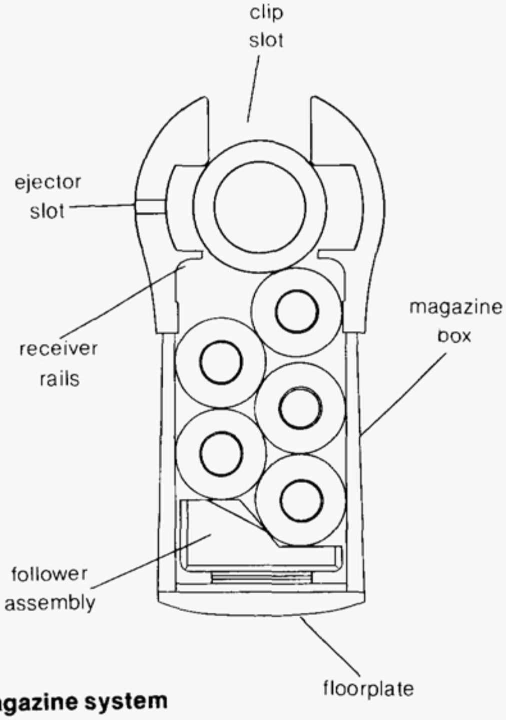
This non-rotary extractor is covered by two Mauser patents, U.S. Patent 467,180 issued Jan. 19, 1892, and 477,671 issued June 28, 1892. Earlier Mausers used smaller and neater extractors recessed in the bolt head and very similiar to many modern commercial patterns. For example, Mauser developed a ring extractor in some respects similar to that now used by Remington, a T-slot extractor very much like the new Winchester Model 70 extractor, and a dovetail extractor like those now used by Sako and Steyr. The larger and more awkward external type, however, provided the functional superiority Mauser required for the military M98.

As noted previously, the M98 bolt face and extractor create a feed sequence safeguarding against double-loading. To assure this is not defeated by by-passing the magazine, the M98 is set up to discourage any habit of feeding cartridges directly. The face of the already-stiff extractor hook is angled to prevent it easily closing on a chambered round.

About 1/32 in. extra clearance is broached into the right raceway at the receiver ring, however, in this and other actions with the external Mauser extractor, and even though the M98 extractor will not cam itself over a case rim, this can be accomplished externally by squeezing its side as the bolt is closed. Without this technique, the Mauser can be easily jammed in the field, particularly when converted for cartridges which do not smoothly feed from the magazine.

A seldom-appreciated advantage of the Mauser extractor is that the wide spring-steel claw achieves its strength with a very thin-sectioned head. Thus it doesn't utilize the entire cannelure, and the cartridge can be seated extra deep in the chamber.

The magazine is a staggered-column top-loaded type, a basic style widely applied to modern bolt-action design and patented under U.S. Patent 527,869 issued Oct. 23, 1894. A flush box formed one-piece with the trigger-guard assembly fits under the receiver and contains a follower and W-shaped ribbon spring to load the cartridges upward. A detachable floorplate supports the follower assembly, while the receiver rails form lips to position the top cartridge for pick up by the bolt.



Mauser M98, magazine system

The double-column pattern permits a good cartridge supply without an excessively deep stock or a protruding magazine. An offset rib on the follower locates the first cartridge against the right receiver rail. Each succeeding round is then positioned on alternate sides by the cartridge below.

Cartridge position in a double-column system must be precise for reliable function. Too wide a magazine, an improperly shaped follower or feed lips, can easily cause a cartridge to wedge in the magazine box or rise to the wrong place and be jammed by the bolt. Mauser's construction forms the lips as part of the receiver rails, with all critical dimensions machined (not stamped) to form a rugged and precise system. The critical feed lips on detachable magazines are usually of sheet metal. This, combined with the fact that the magazine is a separate part subject to rough handling, doubles the possibilities of malfunction. In the Mauser system, not only are the lips part of the receiver itself, but they remain protected deep within the rifle.

There are two basic types of staggered-column magazines, those which feed cartridges from either row to a common point for pick up, and this Mauser type which feeds to alternate sides of the receiver. The receiver rails and feed ramp in the Mauser then steer each cartridge in position for smooth entrance into the chamber. The big advantage of the more open Mauser type, of course, is the ease with which it can be loaded from the top.

The floorplate attaches with lugs in a typical military fashion. Instead of hinging open, it drops completely off. The release system itself is also less than convenient, requiring a bullet or similar object to operate.

By controlling gas flow-back at its source, Mauser's inner-collar breech makes possible an effective gas-handling system. Gas that does escape around the bolt head is released at several places: to the right and top, by the loading/ejection port; to the bottom, out the magazine; to the left side, out the deep thumb cut that vents the raceway. Thus the M98 allows little opportunity for gas to concentrate and channel back between the bolt and receiver. Gas reaching the bridge is deflected outward away from the shooter's face by the flanged bolt sleeve (U.S. Patent 590,271 issued Sept. 21, 1897).

Gas entering the firing-pin hole is released by two large slots (5 x 10 mm) opening into the left raceway (Belgian Patent 120,477 issued Mar. 12, 1896). The mainspring flange helps block remaining flow, but in so doing is subject to a piston-effect tending to drive it from the bolt. Mainspring bottom-out prevents this. In the highly unlikely event this fails, the full-round firing-pin cross section will jam into the mouth of the bolt sleeve. With these dual safeguards, the cocking piece (which is locked by six lugs to the firing pin shaft) cannot snap rearward more than about 7/8 in. beyond full-cock.

The shooter is well protected from a cartridge failure in the M98. This built-in safety factor is an important reason for the universal popularity and respect for the action, and most turnbolt designs strong in this area today pattern after these Mauser principles.

Primary extraction of the fired case, compression of the mainspring, and seating a cartridge in the chamber are all accomplished by hardened cam surfaces on the bolt and receiver. A principal advantage of the turnbolt action over other types of rifle breech mechanisms is the powerful leverage of these cams to assure functioning under adverse conditions. For example, the classic lever-type action gives only about a 2 to 1 leverage. In the Mauser, the bolt handle length, in combination with the angle and location of the cams, gives a mechanical advantage for extraction and chambering of about 8 to 1. The bolt action is thus much less susceptible to jamming, a primary reason for its success as a military arm.

Much emphasis was placed on this aspect in the early years of the metallic cartridge, and properly so. One interesting example was the specifications used for the New York Militia Rifle Trials of 1896 which required "extractor leverage of 10:1." Tests also included extraction of rosin-coated cartridges.

Before examining the details of these cams and their mechanical advantages, it should be noted that they are not simple independent functions. Several factors act simultaneously during bolt operation. The work applied in lifting the bolt handle is absorbed in three ways. Much is simply wasted in friction, depending on tolerances, finishes, and lubrication. The remainder is divided between extraction, which varies depending on how tenaciously the case grips the chamber walls, and mainspring compression. The situation when closing the bolt is similar.

The mechanical advantage data in this book are ideal figures, neglecting friction. Extraction leverage for the M98, for example, is given as 8.5 to 1, but if a 50-lb. lift were applied to extract a stuck case, a 425-lb. pull on the case rim would not result. About 5 lb. of lifting effort is taken by the cocking cams, and much more by friction. Determining average efficiency is difficult. Equally uncertain is the reaction of the extractor claw and case rim under maximum camming forces. The M98's three camming systems are examined in detail below.

Cams on the bolt handle and receiver combine for primary extraction—breaking the fired case free of the chamber walls—during bolt opening. As the bolt is lifted, and just after the locking lugs clear bearing contact in the receiver, the bolt-handle root contacts an angled rear surface of the receiver bridge. This forces the bolt .16 in. rearward as the bolt knob moves 1.36 in. upward, giving about 8.5 to 1 leverage.

Bolt lift also causes the cocking-cam notch in the bolt rim to draw the firing pin back and compress the mainspring. This, combined with about a .02-in. displacement as the bolt sleeve threads a quarter-turn into the bolt, provides the majority (.38 in. or 75%) of mainspring compression. The cocking-cam notch is cut on an enlarged hub at the rear of the M98 bolt. This increases the cam's radius, giving a less acute camming angle. Supposedly the end result is an easier opening motion. Unfortunately, as a little analysis will show, the basic laws of mechanics aren't circumvented so easily.

The M98, as most of the actions in this book, is a *cock-on-opening* design. Cock-on-opening is often equated with accomplishing the majority of mainspring compression during bolt lift. More precisely, it defines an action where the mainspring is compressed entirely by cams, leaving none to be accomplished without cam assistance as the bolt is pressed forward at the beginning of the closing cycle. It thus avoids the tendency to push the rifle off the shoulder when closing. Also it can be cocked by simply raising and lowering the bolt handle, without having also to cycle the bolt back.

This requires that the cocking-cam notch in the bolt rim be deep enough to drive the cocking piece behind the sear and reset the trigger during bolt lift, so that the chambering cams engage first during turndown. While the smokeless-powder Mauser rifles preceding the M98 were cock-on-closing, cock-on-opening was by no means something new, and was employed on many earlier rifles, including the Mauser Model 1871, Commission M88, Krag, Carcano, Mosin-Nagant, and Mannlicher.

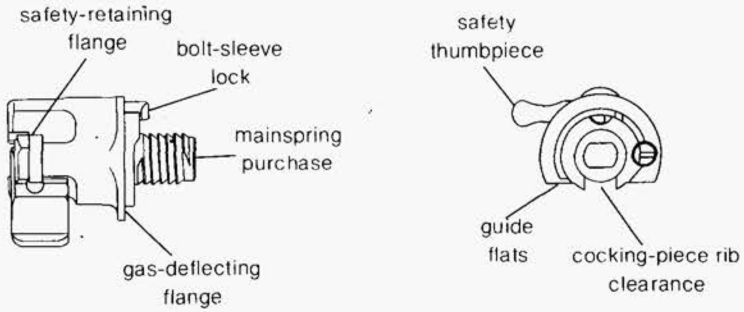
As the M98 bolt closes, helical approaches to the receiver-ring seats draw it .25 in. forward to seat the cartridge. This occurs as the handle is lowered the initial 2.1 in., resulting in a little over 8 to 1 leverage.

Because of their function, these are known as the *chambering* or *closing* cams. Besides providing a powerful advantage to seat the cartridge, they accomplish .12 in., or 23%, of mainspring compression. Compression during closing would be slightly greater, except the action of the bolt-sleeve threads shifts mainspring purchase back about .02 in.

The bolt is closed at the rear by a threaded-on bolt sleeve, covered in U.S. Patent 440,955 issued Nov. 18, 1890, and later refined in U.S. Patent 590,271 issued Sept. 21, 1897. By assuming some of the functions previously associated with the cocking piece, this bolt sleeve permitted a much lighter and thus faster moving firing pin assembly than before.

The M98 bolt sleeve has several functions. It provides mainspring purchase, guides and indexes the firing unit, houses the safety, forms a gas-deflecting flange, and contains the firing pin in the event of a gas blowback. It also houses the bolt-sleeve lock.

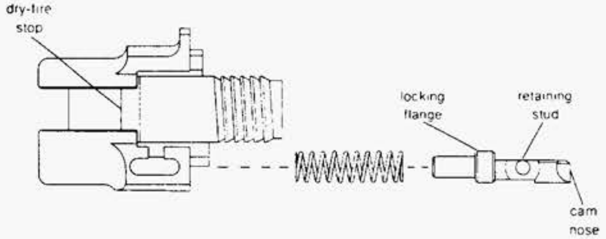
Mauser M98, bolt sleeve



A turnbolt action needs something to index the bolt group (bolt, bolt sleeve, and firing pin assembly) after the bolt handle is lifted, so that it can't accidently uncock or rotate out of position with the bolt drawn back, and then jam on the closing cycle. The easiest way to index these parts is with a small holding notch in the bolt rim. The M98, however, and a few other rifles like the Springfield 1903 and Winchester Model 70, requires a special lock. Each has a safety with a mid-position which withdraws the cocking piece without also locking the bolt. If the bolt is operated with the safety so positioned, the cocking piece cannot bear against the bolt rim to index the parts. This was the case with the first Mausers with the three-position safety, and thus they were prone to accidental uncocking with the bolt drawn back.

The M98 bolt-sleeve lock is a spring-loaded plunger in the left bolt sleeve flange, shifting forward to lock into a bolt rim notch with the bolt fully lifted. On closing, its nose contacts the receiver bridge, pushing back the locking flange to free the bolt for turndown.

The plunger is held in a retaining pocket by spring tension, thus avoiding the need for screws, pins, or detent balls. This typifies the M98. It is engineered for easy assembly and disassembly by hand, with little need for tools.

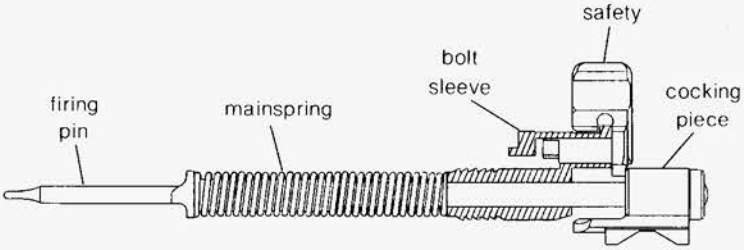


Mauser M98, bolt-sleeve lock

The M98 has a direct three-position safety covered under U.S. Patent 547,933 issued Oct. 15, 1895. It cams the firing pin assembly back completely free of the sear, something which is always necessary in a direct safety like this. If the firing pin assembly only were blocked, and the trigger then pulled, tolerances might allow it to shift far enough ahead to prevent trigger reset, thus leaving the rifle unsafe.

Besides positive action, a safety should also be capable of quick and silent release. Here the M98 does not excel, as the half-turn swing from *safe* to *fire* is neither convenient nor silent.

The Mauser safety is of one-piece construction. Its spindle occupies the top of the bolt sleeve, with the thumbpiece straddling a flange on the left and top circumference. It clears the flange on the right side, but is retained by the cocking piece. Detents in each position are formed by notches in the safety hub. Thus retention and detenting of the safety are again neatly built into the design, requiring no extra parts.



Mauser M98, safety

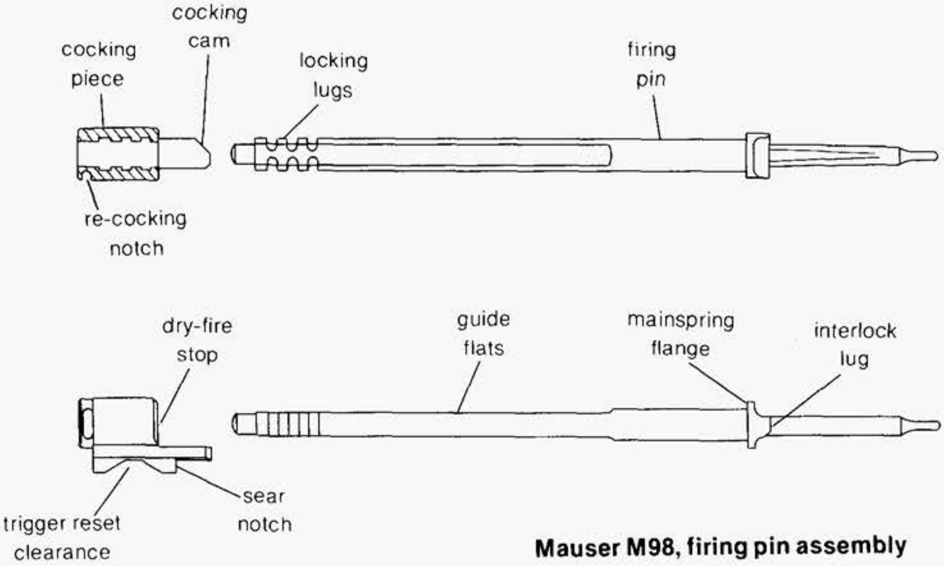
The thumbpiece swings a full half-turn. Turned upright, the safety hub engages the front rim of the cocking piece, camming the firing pin back .05 in. At the same time, the spindle nose clears the bolt rim, allowing bolt lift. The advantages of this intermediate position, justifying the inclusion of the special bolt-sleeve lock which it made necessary, are that it permits working cartridges through the action with the firing pin locked, and it simplifies bolt disassembly.

Turned right to *safe,* both the firing pin and bolt are locked. The safety hub continues in contact with the cocking piece, while the spindle nose now locks into the bolt-rim notch.

Finally, with the thumbpiece turned left to the *fire* position, the firing pin assembly is eased back onto the sear. A cutout in the safety hub lines up ahead of the cocking piece and the spindle turns clear once again of the bolt rim, freeing both the firing pin and bolt.

The ejector and bolt stop are combined in a swing-out box hinged to the outside of the left wall of the bridge (U.S. Patent 431,668 issued July 8, 1890). The ejector blade is pivoted and spring-urged through the wall of the bridge into the centerline of the bolt, requiring also a slotted left bolt locking lug for passage.

As the bolt is drawn back, the ejector springs inward to strike the cartridge and flip it out the loading/ejection port. Some M98 ejector blades were made with an elongated pivot hole to cushion and protect the blade by allowing it to move back and spring the box wall out slightly under a heavy blow.



Mauser M98, firing pin assembly

Performance of the M98 lock can serve as a basis to compare later turnbolt designs. Its mainspring gives a moderate average driving thrust (about 17 lb.) over a fairly long distance (about ½ in.) to achieve a high energy and impulse blow (about 130 in.-oz. and 1.4 oz.-sec.). The significance and relation to performance of these parameters is covered in later chapters.

Lock time is just over 5 milliseconds (ms.), slow by today's standards, yet very good in its day. In fact, compared to many non-turnbolt type actions, it was exceptional. Even today's automatics, pumps, and lever rifles, with their swinging or hammer type lock mechanisms, usually can't match it.

A final and particularly interesting aspect of the Mauser firing mechanism is a special *interlock* to block the firing pin when the bolt isn't closed. It's interesting not so much because of how it works, but how it illustrates to what lengths the designers of these early bolt actions went to make them foolproof. As with the precautions described earlier which Mauser took to prevent double-loading, such a firing interlock is left completely out of most modern bolt-action designs.

Earlier Mausers had a trigger interlock (U.S. Patent 488,694 issued Dec. 27, 1892), where sear movement is blocked unless the bolt is fully closed. An even earlier version of the same idea was described in the first Mauser patent, No. 78,603 issued June 2, 1868. This system worked well, and was also later used in the Japanese M1905 and the U.S. Enfield M1917. Its value, however, was not actually protection against firing a cartridge with the bolt unlocked. If the trigger releases before the bolt is fully locked, interference between the cocking piece and bolt rim does this, either blocking firing pin fall or turning the bolt closed and thus de-energizing striker fall. If the cartridge does fire, the locking lugs are then engaged anyway, since the firing pin can't get where it's going until the bolt is spun closed.

Mauser's earlier models, as well as the Arisaka and Enfield, were cock-on-closing. Some believe this accounts for the trigger interlock. In other words, cock-on-opening actions don't use it because their larger cocking-cam notch can better stop striker fall. The firing pin cannot penetrate with the bolt significantly open with either type, however, and if anything, the cock-on-closing pattern is even more positive in blocking striker fall.

Avoiding misfires was the real value of this first interlock system. By signaling the shooter he was trying to fire a partially open action, the bolt handle could be immediately lowered to fire, rather than a cycle of misfiring the rifle, followed by re-chambering, or at least re-cocking, a potentially fatal error in combat.

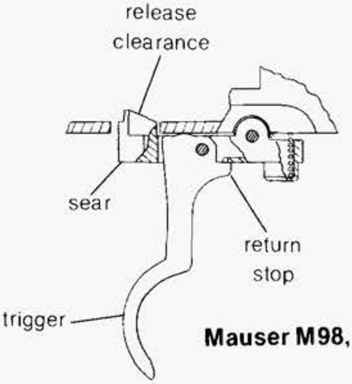
With the introduction of the M98, the trigger interlock was dropped for two reasons. First, the more balanced camming setup in its cock-on-opening system made it more difficult to avoid the interlock from jamming the bolt on opening. Second, the new action could be restored to firing condition much faster after a misfire of this type.

The subject was not dead, however, and in 1902 a second interlock was introduced, this time involving the firing pin directly (D.R.G.M. 154,915 issued May 22, 1901). The mainspring flange was provided with two forward-facing lugs which must enter matching recesses inside the bolt for the striker to reach full protrusion. They align only with the bolt closed (or more correctly, at least partially closed, as noted below).

These interlock lugs actually only function when the bolt is at least 20° open. In contrast, both the earlier trigger interlock and the natural interference of the cocking cams will block the firing pin assembly before the bolt is raised 10°.

Obviously, then, this *safety firing pin* was not intended to duplicate the function of the earlier trigger interlock, or accomplish what it is often credited with, the popular notion of simply preventing firing pin fall unless the action is fully locked. Its function is to prevent ignition should the firing pin shaft break, or the cocking piece come loose or break, during bolt closure. To cause a blow-up, this would have to occur after a cartridge is stripped from the magazine—if the extractor grip permits ignition—and before the bolt is locked. Because of these limited possibilities, and the extremely sturdy nature of the M98 firing pin assembly, this second Mauser interlock system was actually less important than the first.

The military Mauser had a *double-draw* or *double-pull* trigger, a simple and rugged mechanism of only five parts and without adjustments of any kind. The trigger and sear move together, giving a long total trigger pull, but one well suited for military purposes as it is compatible with rough handling and nervous trigger fingers. At the same time, the two stages do permit a useful final pull.



Mauser M98, trigger assembly

The above is accomplished by a double-pivot mechanism, where the trigger pin floats and the sear pivots directly to the receiver. Two humps on the head of the trigger piece operate in sequence as fulcrums under the receiver, camming the sear down. The first gives smooth and gradual take-up of initial sear engagement, or *slack*. When contact shifts to the second hump, or *heel*, the small remaining engagement, or *creep*, is released in a more sharp and crisp manner.

Although sear engagement is initially square to the firing pin axis, the sear pivots rather than sliding straight downward, and so its movement cams the cocking piece slightly rearward. Thus, trigger movement in this direct-pull system must actually compress the mainspring slightly. By the same token, however, this geometry safeguards against trigger release if the cocking piece is accidently struck from behind and it also assures retraction, as noted below.

When pressure is released from a partially squeezed-off trigger, it should *retract* or return to full original engagement. Otherwise the firearm is left unsafe and liable to unintended discharge. The M98 trigger is patterned so that mainspring pressure acts along a line passing above the sear pivot, thus forming a component always forcing the sear upward into full engagement. To lighten and smooth trigger pull, the sear face is sometimes radiused to align mainspring pressure directly into the pivot, and thus reduce or eliminate rearward camming. This, however, also eliminates an important safety factor built into the Mauser trigger. If overdone, so that negative camming results, inherent safety is totally lost.

Summary

Mauser's M98 was the superior bolt action of its time, and it is a remarkable tribute to his accomplishments that even today it remains a top choice. Its features were carefully selected compromises, drawn from a vast design background. These were the years when Paul Mauser, and others, established the important bolt-action design principles. It's surprising how many apparently new ideas seen today can be traced back to this era, forgotten because so few of the early bolt-rifle designs have survived.

The M98 action continues to this day virtually unchanged from that detailed by Paul Mauser in the fall of 1895. It was a highly versatile design, successfully made in a far-flung collection of armories, possessing varying levels of machining and metallurgical skill. This has been possible because Mauser engineered the strength and safety into the design. Loading and stress levels were carefully distributed, making ultra-high-strength steels and sophisticated heat treatment less critical.

The M98 was strongly shaped by military needs. Had Mauser instead focused on the commercial market, a smoother and more streamlined action would doubtless have evolved. And on the other side of the coin, were the Army even today seeking a general-purpose bolt-gun, the M98 would clearly outpoint most contemporary designs. The following summarizes the strong and weak points of the M98 action:

Strong points:

1. Strong breeching and gas handling.
2. Positive extractor system.
3. Neat and effective safety lug.
4. Simple overall mechanical design.
5. Positive and controlled ejector.
6. Direct-acting safety.

Weak points:

1. Lack of receiver rigidity and bedding due to the notched siderail and slender tang.
2. Slow lock time.
3. Inconvenient floorplate design.
4. Bolt-handle shape and safety limiting scope placement.
5. Direct-pull trigger.

MAUSER M98

Dimensions

OPERATING

Extraction: set-back—.16 in.
leverage—8.5 to 1

Chambering: cam-forward—.25 in.
leverage—8 to 1

Bolt rotation—90°

Bolt travel—4.55 in.

Operating forces: bolt lift—5 lb.
(see *Note*) press-forward—2.5 lb.
bolt turndown—6 lb.

Cock-on-opening: .511 in.
mainspring compression
proportioned as follows:
opening—.383 in.
closing—.117 in.
trigger pull—.011 in.

IGNITION

Firing pin travel: at impact—.468 in. (to initial impact on primer)
dry-fired—.511 in.

Lock time—5.2 ms. (See Appendix for calculation)
Impact velocity—15.1 ft./sec.
energy—130.2 in.-oz.
impulse—1.44 oz.-sec.

Striker/firing pin hole diameters—.075 in./.080 in.

Note: Operating forces were measured with a fully sized case, to avoid actual extraction and chambering forces. These would vary widely depending on the condition of the case and chamber, and thus not consistently define the efficiency of the camming systems. However, a fully sized case does factor in such things as extractor engagement and ejector setting, where they apply. Besides lift and turndown, a significant press-forward effort occurs in many actions, due to a variety of factors. In the M98, the heavy bolt-sleeve lock offers resistance. In cock-on-closing actions like the M1917, mainspring tension is the culprit. On multiple-lug actions like the Weatherby, the extractor contacts before turndown can begin. All of these operating measurements were obviously very susceptible to the finish, fit, and lubrication in any particular rifle. Nevertheless, significant design differences are revealed. To minimize erroneous conclusions, each sample action was checked for condition and properly lubricated.

RECEIVER

Overall length—8.74 in.
Length of loading/ejection port—3.08 in.
Ring diameter—1.415 in.

Barrel/receiver threads: designation—1.1-12 (55° V-form)
engagement—.50 in. (6 threads)

Recoil lug: width—1.07 in.
height—.23 in.
thickness—.41 in.
bearing area—.24 sq. in.
clearance from magazine—.95 in.

Guard screws: front—¼ x 22
rear—¼ x 22

Scope mounting provisions—none

BOLT

Lug shear area—.316 sq. in.
Lug bearing area—.054 sq. in.
Bolt diameter—.695 in.
Lug diameter—.963 in.
Bolt face: type—semi-recessed
depth—.046 in.

MAGAZINE

Length—3.32 in. (max. cartridge length)

Depth (receiver centerline to outside of floorplate)
front—1.90 in.
rear—2.07 in.

Capacity—5

WEIGHT

Receiver group—18.0 oz.
(includes trigger and bolt stop/ejector assemblies)

Bolt group—16.1 oz.
(includes bolt sleeve, extractor, and firing pin assemblies)

Magazine/floorplate group—11.1 oz.
(includes guard screws and spacers)

Total action weight—45.2 oz.

OPERATION

The following traces through an operating cycle of the Mauser action, beginning after firing, and keeping in sequence as much as possible.

The re-cocking process starts immediately with bolt lift. As the bolt turns, the cam slope cut into its rear rim rotates against the cocking piece nose, pulling the firing pin back into the bolt to start mainspring compression. Near the top of bolt lift, the cocking piece has been driven fully back out of the cocking notch and moves off onto the bolt rim proper. It remains in this partially cocked position until later picked up by the sear and fully compressed on the closing cycle.

About midway through bolt lift the extraction cams come into play. The bolt cannot move back while the locking faces engage. As soon as they clear, the bolt-handle root contacts a cam ledge cut on an angle across the roof of the receiver bridge, forcing the bolt a small distance rearward during the remainder of lift. Since the extractor has the cartridge head in its grip, this short, but powerful, cam set-back pulls the expanded case free of the chamber, providing what is termed primary extraction. During all this, the extractor remains locked from turning by the right raceway, so that the twisting bolt movement is translated to a straight pull on the case-head rim.

Bolt rotation stops when the locking lugs enter their raceways in the receiver ring. The action of the cocking cams, combined with the rearward displacement from the extraction cams, has now positioned the cocking piece behind the sear, resetting the trigger. Also, the plunger nose of the bolt-sleeve lock is now clear of the bridge, allowing its flange to lock the bolt and bolt sleeve together.

As the bolt is drawn back to complete the extraction process, it is guided and supported by the locking and safety lugs. After moving a short distance, the guide rib engages its groove under the bridge roof for added support. The extractor drags the cartridge case rearward until it is struck by the ejector and flipped out the loading/ejection port. When the bolt clears the magazine, the next cartridge rises between the receiver rails and into feeding position.

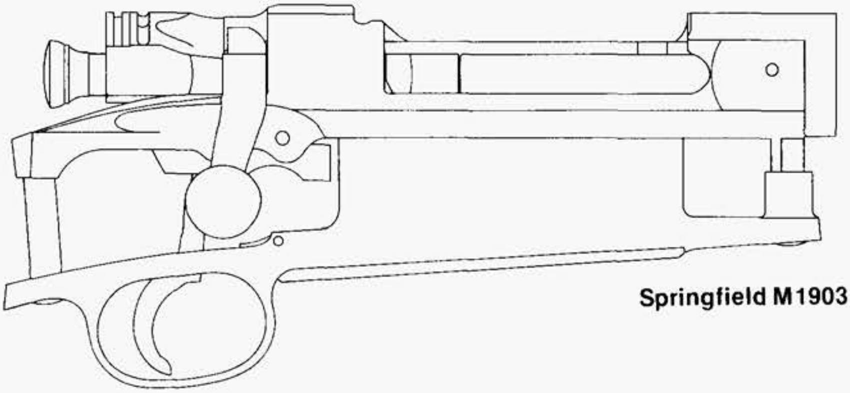
Slid forward to begin the closing cycle, the bolt catches this top cartridge, stripping it forward. The receiver rails gradually release the cartridge and its base is guided up under the extractor by pressure from the magazine spring. The cartridge is closely controlled by the bolt, more so than in those modern bolt actions with counterbored bolt heads and sheet-metal feed lips.

As the bolt is lowered and moved slightly forward by the lug/seat cams, the sear picks up the cocking piece. The locking lugs cam the bolt fully ahead as they turn into their seats, chambering the cartridge and completing mainspring compression. When the bolt-handle root contacts the rear tang, the action is ready to fire. The cocking cam notch lies forward of the cocking piece and the cuts in the bolt interior are aligned with the interlock lugs on the mainspring flange.

Trigger pull cams the sear under the cocking piece, allowing the mainspring to snap the firing pin forward. Impact against the primer stops striker fall, about .035 in. short of full protrusion. Ignition expands the cartridge body and neck out against the chamber walls. Rearward movement is blocked by the bolt, driving the locking lugs into their seats. After chamber pressure subsides, the cartridge brass springs back just enough to permit opening the bolt to begin another cycle.

2

Springfield M1903



Springfield M1903

The Springfield M1903, officially designated "U.S. Magazine Rifle, Model of 1903, Caliber .30," was issued as the service arm for the U.S. Army beginning in 1904. It developed from a careful, if not entirely productive, study of Mauser rifles and incorporated the important Mauser principles, while at the same time retaining a good deal of style and detail from the Krag.

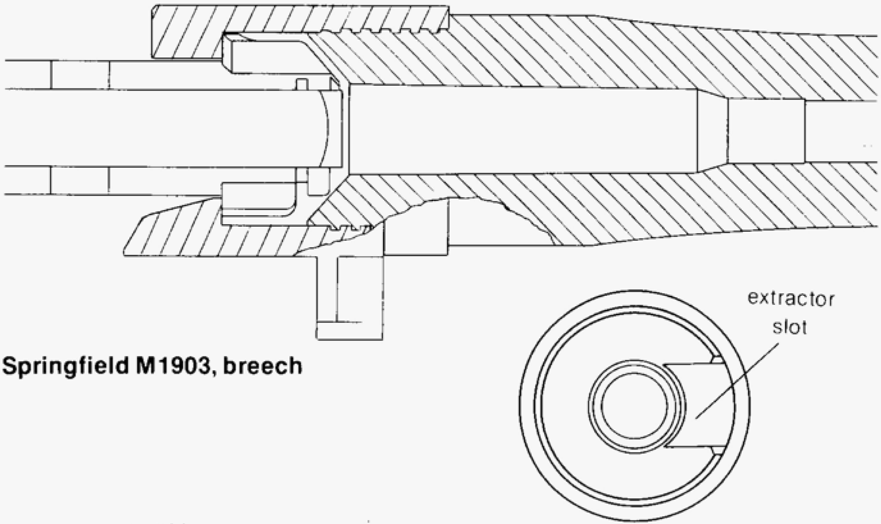
The developing Mauser systems were under study by the War Department for many years. Following the success of the Spanish Mauser in Cuba, a project to replace the Krag began in earnest. Prototype Models of 1900 and 1901 were evaluated and rejected by review boards. The third, the Model of 1903, was recommended for adoption on March 28, 1903, and approved for manufacture by the Secretary of War on June 19, 1903.

The M1903 was manufactured at Springfield Armory and Rock Island Arsenal. Rock Island production ended after World War I, while that at

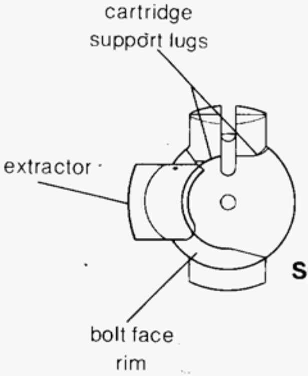
Springfield Armory continued on a limited scale until 1939. Large-scale manufacture resumed during World War II at Remington and Smith-Corona; however, these were mostly the later 1903A3 and 1903A4 versions. The machine tools formerly used at both Springfield Armory and Rock Island Arsenal were shipped from storage at Rock Island to Ilion for Remington production. Smith-Corona used new machine tooling.

The detailed history of the Springfield's manufacture, its material and heat-treatment changes, and the relative merits of these variations, are all in print. This chapter will therefore concentrate instead on the basic design aspects of the M1903.

A fundamental deviation from the Mauser M98 is the cone breech. The rear of the barrel is deeply funneled, with the bolt head shaped to a similar angle. A close-fitting slot milled into the right wall of this cone provides clearance for the extractor.



Springfield M1903, breech



Springfield M1903, bolt face

Supposedly, this is not as strong as the Mauser breech, or for that matter most modern commercial patterns. But why? Is the cone inherently weak, or is there something faulty about its application to the Springfield? If it is weaker, to what extent? What are its offsetting advantages?

In theory, the cone is not really that weak. But, in order to decrease any susceptibility to jam from dirt, it is cut further into the chamber than otherwise necessary, and the cartridge head protrudes about .040 in. more than in the Mauser M98 (cartridge-head protrusion in the Mauser is only .105 in., while ordnance drawings for the Springfield specify .147 to .1485 in.). Were the cone brought back, even to contact the bolt head, however, protrusion would still exceed that in the Mauser, and it would actually be necessary to modify the bolt-head pattern somewhat to get it deep enough into the barrel cone to achieve a comparable cartridge head protrusion. From a strength standpoint, the Springfield also lacks Mauser's *inner collar* concept for gas blockage and receiver-ring reinforcement.

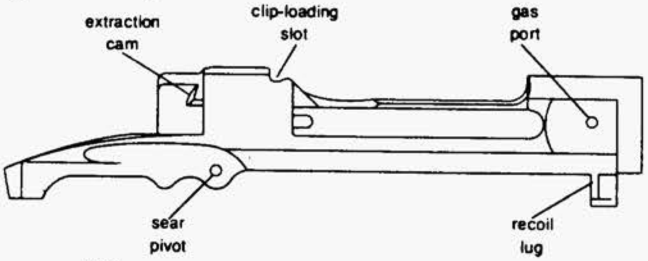
Since the Springfield bolt head is a typical military pattern with little more than a superficial rim, the circumference of this exposed cartridge head receives little support or shrouding. The significance of the resulting *breech gap* is arguable. The .30-06 cartridge head web extends a minimum of .18 in. forward of the base and is solid enough to oppose expansion without support from either the bolt or barrel. No centerfire bolt rifle that ever got off the drawing boards and into production exposes anything but this strong head-section of the cartridge. Everything else is locked inside the chamber walls.

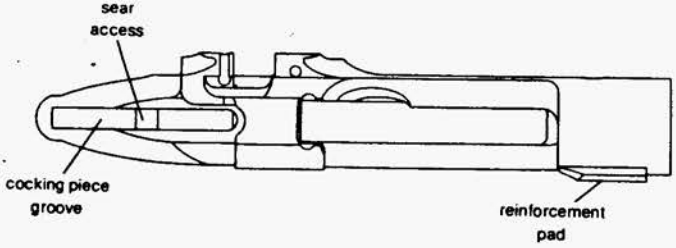
The percentage of the cartridge head encircled by steel, therefore, could be counted as academic. Unless a cartridge head fails, a rifle like the Springfield can be fired a lifetime with no practical disadvantage. This is exactly what applies to all but a few of the millions used over the years, and thus an analysis like this usually makes little impression.

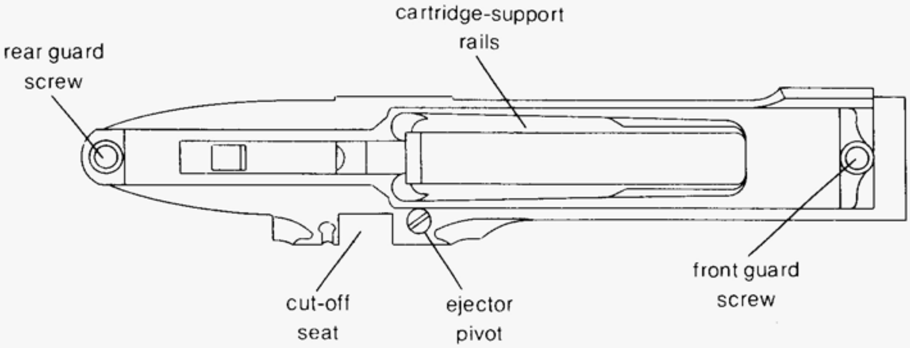
The close breeching systems in many modern bolt actions, with breech gaps as small as .010 in., come into play only if the brass cartridge head does begin to flow or collapse. Then shrouding and support from the bolt rim become vital in limiting the effect. In other words, while a breech pattern like the Springfield's will not in itself cause a case-head failure, neither will it be much protection if one occurs.

On the positive side, the ramp-type entrance, without corners or obstructions, of the Springfield breech allows the smoothest and most positive cartridge feed possible. Because of this, the M1903 was considered by most experts of the day to be significantly superior to the Mauser M98 in this respect. Historically, however, this design detail in the Mauser M98 and Springfield M1903 rifles reflected a basic divergence in battlefield tactics between the armies of Germany and the United States. The German Army had by then fully embraced the use of magazine rifles, the U.S. Army had not. The Springfield rifle had a magazine cut-off, enabling its operation as a "single loader" as well as a magazine arm. With cartridges entering the chamber from various directions, the cone breech was vital for reliable feed. In the Mauser, cartridges fed only from the magazine. The much closer control over their path of movement made a feed cone much less important. So evaluation of the cone breech must consider conditions at the time it was adopted. For modern sporting purposes, rapid and reliable functioning, while highly desirable, is seldom a matter of life or death. Back when these rifles were primary battle weapons, feed and extraction were paramount considerations. Case-head blowouts were unlikely with standard military ammunition, and thus jammed rifles were actually a far more dangerous potential in combat.

Springfield receivers were machined from steel forgings—either carbon or nickel steel, depending on when manufactured—and are a basic siderail pattern. External deviations from the Mauser include a built-up area for the ejector and bolt cut-off assemblies and an elevated bridge for safety-lug clearance. There is also a reinforcing pad on the receiver ring over the extractor clearance. The Mauser type non-rotary extractor makes necessary an extra-deep right raceway in the receiver ring. Mauser compensated by increasing the ring diameter from 1.3 in. in previous models to a little over 1.4 in. in the M98. To save weight, the Springfield designers retained the basic 1.3-in. receiver ring and instead simply added a .1 in. high slab to the right side. The result is a significantly thicker wall over the right raceway than in the M98, although in overall resulting strength, the big Mauser receiver ring is certainly more effective.







The Springfield receiver started as a 4 3/4-lb. drop-hammer forging, finishing up a shade under 1 lb. Four primary locating surfaces were used, in various combinations for each machining operation. The first step, after squaring off the rough forging with a gang mill, was deephole drilling and reaming of the bolt-well bore. A push-fit mandrel was then fitted as the locating means relative to centerline for many subsequent operations. The left side, bottom, and front face of the receiver were then finish-milled flat and true for the remaining reference points.

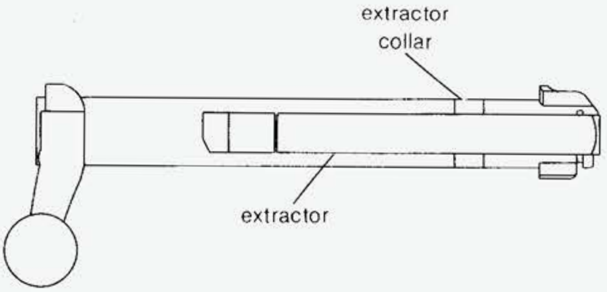
The receiver was rather elegantly patterned, and considering its size, required a remarkably long series of machining operations (almost 100). An extensive application of fixtures, of form, gang, and profile milling, and of special gaging, made its manufacture, as well as that of the entire action, one of the most advanced in the ordnance field at that time. In fact, a large and very interesting book was written on the manufacture of the Springfield rifle (*United States Rifles and Machine Guns* by Fred H. Colvin and Ethan Viall) to help spread this technology to other areas of manufacturing.

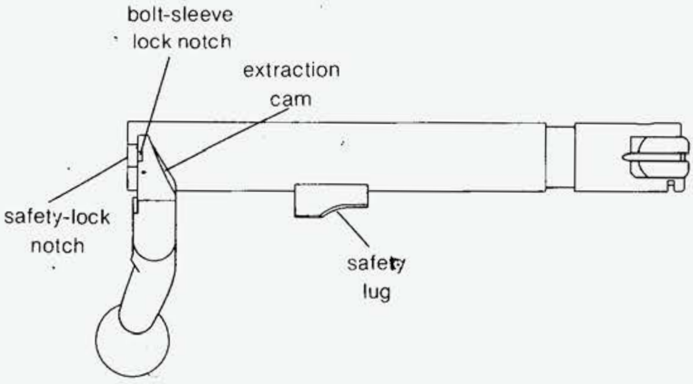
Front and rear guard screws clamp the receiver. The rear screw angles slightly forward and is bushed to prevent springing the receiver or trigger guard. A bushing in the floorplate serves the same function for the front guard screw, plus aligning the receiver and floorplate correctly. This bushing of the guard screws was common to early military bolt rifles, but of questionable value. To function properly the action must bed tightly in the wood. Under ideal conditions, the bushings only limit stock compression and are thus useful. But if the wood eventually shrinks or compresses, tension can transfer to the bushings.

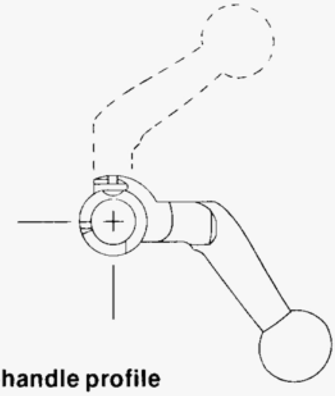
The angled-forward rear guard screw of the Springfield was another feature of questionable merit and was actually dictated by configuration rather than function. It is best to tension the receiver rearward, as well as down, to insure steady recoil-lug bearing. This is often accomplished commercially by slightly offsetting the front guard-screw escutcheon. Ruger formalized the practice, building a large rearward angle into its Model 77 front guard-screw pattern (U.S. Patent 3,444,641 of May 20, 1969 [W. B. Ruger]). The Springfield forward-angling rear guard screw works opposite, tending to draw the recoil lug forward, out of contact.

Dimensionally, the Springfield recoil lug was only slightly better than the Mauser's, and thus the issue stock has a reinforcing cross-bolt. The action beds on a flat surface behind the recoil lug about equal to the Mauser's in size. Yet bedding in the Springfield is stronger and less temperamental because its heavier rear tang and midsection make the receiver less susceptible to being sprung by imperfect wood-metal support.

The bolt is machined from a single forging (of the same steel as used in the receiver), and drilled out from the rear for the firing unit. There are two bolt head locking lugs. The solid right lug is set slightly back to clear the extractor as the bolt opens. The left lug is higher and extends forward, sloping down to form a cartridge-support ridge opposite the extractor. Because of the ejector slot, it is often assumed to be weaker than the right lug. While this is so in the Mauser M98, the Springfield's left lug has just enough extra length and height to balance the lug strengths.







Springfield M1903, bolt-handle profile

These lugs turn 90° to vertical to lock into the receiver ring, with the final 50° devoted to lug/seat locking contact. This puts more emphasis on the locking phase than the 60/30 distribution in the Mauser M98, although still less than in some later commercial designs. The Remington 721/722 series, for example, has a 30/60 distribution.

There is also a large safety lug on the bolt. Rather than copying the Mauser M98, it is a quarter-turn out of line with the bolt-head lugs like the Krag, thus utilizing the front wall of the bridge as the potential locking seat and avoiding the need to cut a special locking recess. At the same time, however, this location created its own complications and was a problem from the rifle's inception. Since it locks outboard of the right raceway, which is extra deep for extractor passage, the safety lug must be very high. The first prototype (Model 1900) had an open bridge for passage. This left the receiver subject to warpage during heat treatment, and it was closed over in the next version (Model 1901). The lug was trimmed down to avoid raising the bridge higher than the ring, in the process giving it little potential purchase. In the M1903, the lug was restored to its original height (.3 in.) and the bridge raised to cover over the clearance slot. So in contrast to the trim and unobtrusive Mauser safety lug, the Springfield system is clumsy, requiring a bridge approximately 1/10 in. higher than the ring.

The extractor copies the Mauser, except, being shorter to clear the safety lug, it bears only in the receiver ring during extraction. In theory, at least, this allows more of a binding tendency than in the Mauser where the extractor is supported from turning both fore and aft of its collar. The extractor face is beveled to readily close on a chambered round, making single-cartridge loading an easy and convenient procedure. Once engaged, however, it takes a deep and positive grip on almost one-fourth of the cartridge rim.

The magazine and floorplate assembly copy the Mauser, with a heavy one-piece frame and precision-machined follower, although later versions had stampings for these parts. The follower lacks an override bevel, so that the bolt is blocked open over an empty magazine. The idea behind this was to prevent a soldier from continuing to operate an empty rifle in the stress of battle. Practice in bolt manipulation was still possible, however, because of a unique *cut-off* assembly which can be set to stop the bolt just before it clears behind the follower.

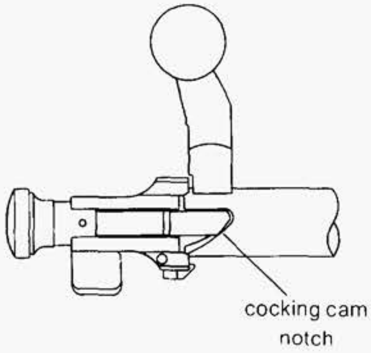
The original M1903 had a small gas port in the right side of the receiver ring. A larger port was later added to the left side to align with a port in the bolt head. Despite these precautions, the M1903 then has very little to oppose that gas which does escape behind the ring area. About the only protection for the shooter's face and eyes is the flared cocking knob.

Another consideration is firing pin blowback. Gas leakage into the bolt interior can create a piston effect tending to drive everything out the rear of the bolt. Despite its gas ports, the Springfield suffers this tendency, and with only marginal safeguards. While mainspring stack-up blocks a rearward-blown firing pin at about 1/4 in. beyond full cock, the mainspring collar unfortunately is part of a jointed firing pin head. If it should fail, the firing pin rod is free to escape. In this regard, there is also evidence that when the bolt is expanded by escaping gas the shallow square-form Springfield bolt-sleeve threads are more susceptible to letting go than normal V-threads or the Mauser buttress type.

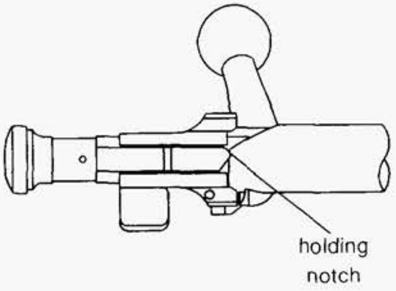
In contrast to the Springfield, modern bolt actions usually include more than ample protection in this area. The Remington 721/722, for example, has a heavy integral mainspring flange on the firing pin head. Many designs go further. The Mauser M98 backs up mainspring stack-up by interference between the firing pin shaft and the bolt sleeve. A similar dual system, except with a wedge rod, existed on the pre-'64 Winchester Model 70. Finally, latest trends favor a shrouded bolt sleeve to block both the firing pin and escaping gas. Examples are the Weatherby Mark V, Texas Magnum, and Remington Model 788.

The Springfield's camming systems are ideally patterned, combining large displacements with powerful leverages, and in large measure account for its reputation for fast, easy, and slick operation. The bolt almost seems to want to work itself. Lift is comparatively light, despite the large percentage of mainspring compression accomplished, and closing resistance is almost negligible. This, combined with the close tolerances and fine finishes of the bolt and receiver parts, adds up to perhaps the Springfield's greatest strength.

In practical terms this is a vital aspect in any weapon. The smooth and almost effortless functioning of a well-finished and well-regulated Springfield explains and perhaps justifies the many knowledgeable authorities who over the years have rated it over the stronger and safer Mauser.



Uncocked



Cocked

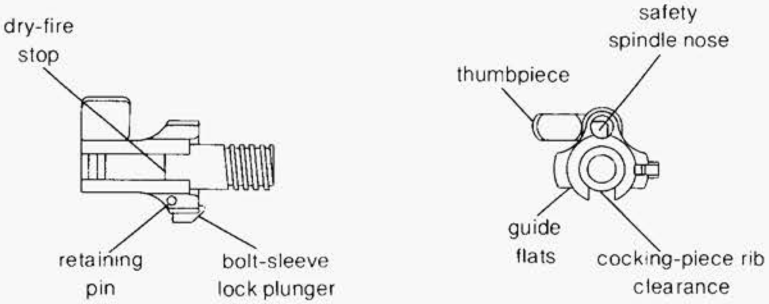
The extraction cams are superior in detail to those in the Mauser M98. The receiver cam is inside the bridge and the bolt cam is formed by the long sweeping flange on the bolt handle. This durable arrangement (later copied in the M1917 Enfield and the Winchester Models 54 and 70) provides an extra-wide contact area to distribute any pounding forces.

A threaded-on bolt sleeve provides mainspring purchase, guides the firing pin assembly, and houses the safety. Since the safety can deactivate the holding notch, the bolt sleeve also contains a locking device to index the bolt group. This comprises a small outward-locking latch in the left bolt-sleeve flange. As the bolt is drawn back, the latch clears the inside wall of the bridge, permitting its nose to spring outward and lock into a small notch in the bolt-handle collar.

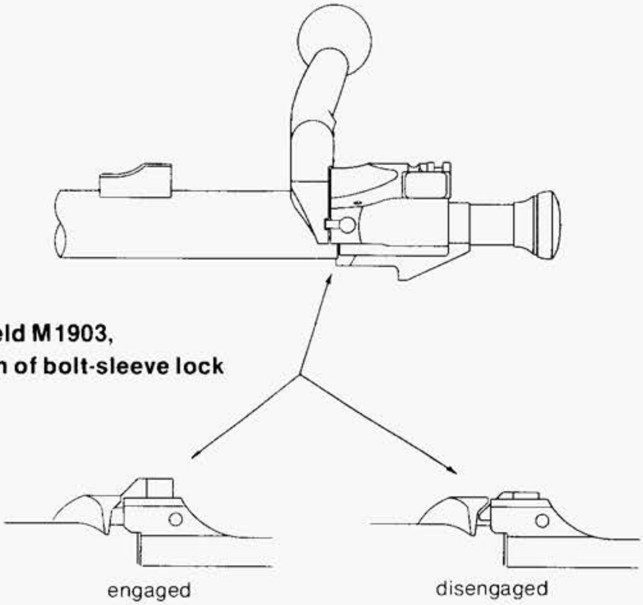
On closing, the latch is cammed inward to release the bolt. This occurs just as the bolt lugs reach full travel, thus avoiding hesitation in the closing sweep. In fact, since the plunger cams inward against a light spring, there is actually little perceptible resistance, giving a much lighter and smoother closing motion than in the Mauser. The inward camming also makes it easier to properly sequence its operation with bolt turndown. On the negative side, however, this system did not prove quite as positive or reliable as the Mauser plunger, being more susceptible to gumming up and battering.

The safety is a three-position type with a wing or thumbpiece swinging a full half-turn over the top of the firing pin axis. It is retained by a spring plunger riding in a groove on the top circumference of the bolt sleeve. Flats at both ends of this groove detent the thumbpiece, while a small bevel on the left edge permits disassembly.

Functioning is like the Mauser safety. Turned to the upright position, locking flanges engage the cocking-piece head to cam the firing pin rear-


dry-fire stop
retaining pin
bolt-sleeve lock plunger
safety spindle nose
thumbpiece
guide flats
cocking-piece rib clearance

Springfield M1903, bolt sleeve


engaged
disengaged

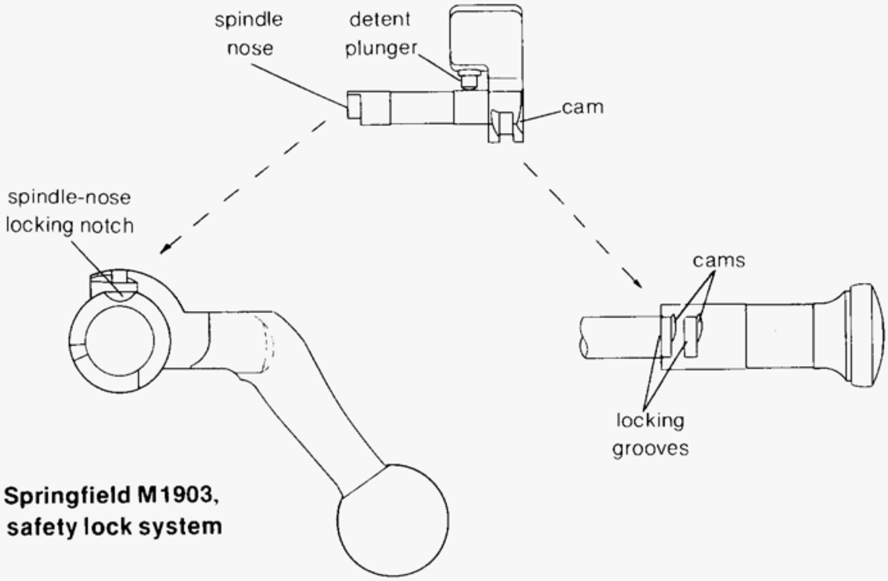
Springfield M1903, operation of bolt-sleeve lock

ward, while at the same time the bolt remains free so that it can be cycled to empty the magazine.

Swung a quarter-turn to *safe*, the locking flanges continue to engage the cocking piece, while the nose of the safety spindle now also locks into the bolt.

Finally, swung all the way over left to *ready*, both the locking flanges and spindle nose disengage, easing the firing pin assembly back onto the sear and freeing the bolt.

Despite the functional similarity, construction of the Springfield safety lacks the ingenious simplicity of the Mauser. Like the Krag unit before it, the Springfield safety is fabricated of four pieces—the thumbpiece, spindle, plunger, and spring—and must be driven off the bolt sleeve.

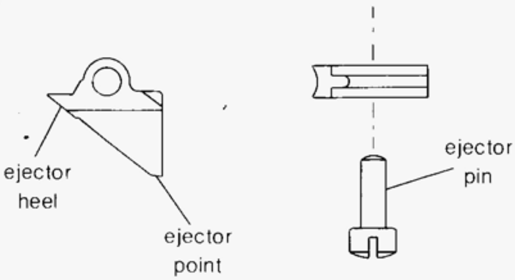

spindle nose
detent plunger
cam
spindle-nose locking notch
cams
locking grooves

Springfield M1903, safety lock system

Nevertheless, the Springfield system is good. It offers the Mauser advantages: Cartridges can be worked through the action with the firing pin locked directly, and the bolt can be stripped without tools. It also resembles the Mauser in that convenience of operation is not a strong point.

The Springfield ejector is impact-operated as in the Krag. As the bolt is drawn back, the ejector is kicked into position behind the cartridge by the left locking lug. This eliminates the Mauser spring and its tension against the bolt, but at the same time much of the energy absorbed from the left lug serves only to overstress and eventually tends to fracture the blade. In this respect it differs from the Krag system where inertia of the ejector blade kicks the cartridge out the ejection port.

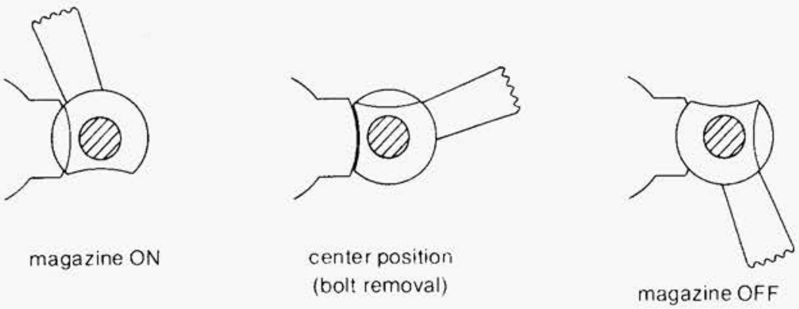
Springfield M1903, ejector assembly


ejector heel
ejector point
ejector pin

The bolt stop is a unique three-position mechanism termed the *cut-off assembly*, since it also controls the magazine. It turns on a lengthwise spindle and has a hub divided into three sectors. Detent notches sequentially align these sectors with the left raceway. With the thumbpiece turned down to the *off* position, a solid sector blocks the raceway. This prevents the bolt from moving far enough back to strip cartridges from the magazine (which is thus *cut-off* or held in reserve) and the rifle can operate only single-shot.

The M1903 was one of many military bolt action rifles employing a system for isolating the magazine in reserve. Pre-World War I U.S. combat tactics called for loading the rifle single-shot, with the magazine kept in reserve for emergency only. In contrast, German tactics of the time emphasized magazine fire, and not only did the Mauser M98 lack a magazine cut-off, but it was actually set up to prevent single-loading.

The other positions of the Springfield cut-off correspond to the conventional bolt stop. In the center detent, a cut-away sector allows bolt removal. In the upper or *on* position, a partially cut-back sector permits full bolt travel and thus normal magazine operation. The rifle is carried and operated with the cut-off at either the upper or lower position, where the thumbpiece lies close to the receiver. It protrudes only in the temporary center position.



Springfield M 1903, operation of cut-off

While this is a reasonably trim and efficient assembly, it does have a couple of drawbacks. First, it lacks an automatic reset. If the bolt is removed for a quick check during competition or combat, and then hurriedly replaced without resetting the cut-off, it is entirely possible to pull the bolt right back into your nose or off into the mud following the next shot. Perhaps more important, the cylindrical stop surface catches a relatively small portion of the left locking lug, presenting more potential to batter the lug bearing face than the Mauser bolt stop.

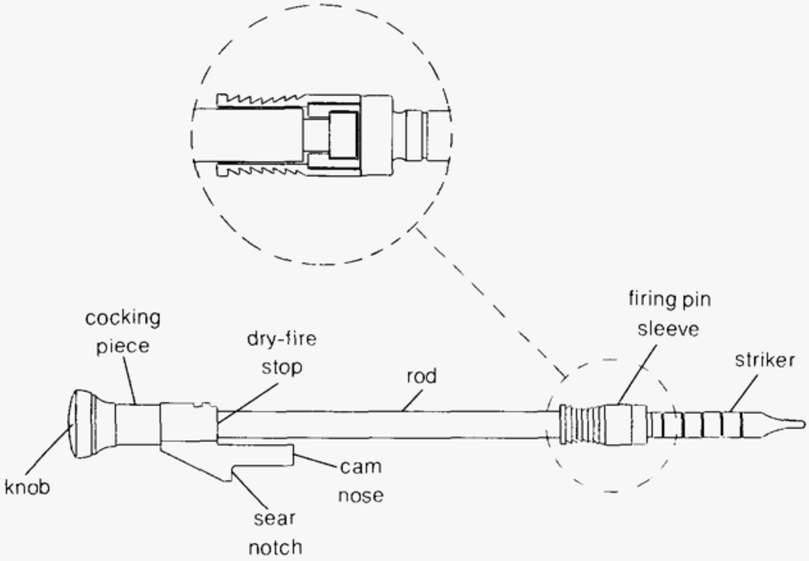
The Springfield *bolt stop assembly* was actually simply a small spring-loaded pin in the raceway floor. It engaged one of two notches in the lower flank of the left locking lug to detent the bolt open, either in the single-shot or magazine position, depending on the cut-off setting. By holding the bolt open against gravity when the muzzle was pointing down, it left the right hand free to charge the magazine or to drop a cartridge directly into the chamber. The idea was good, but the extra drag it created in an action emphasizing slick and effortless functioning more than offset its usefulness. It was not carried over to World War II actions, and was removed from earlier rifles returned for armory repair.

A two-piece firing pin is another Krag carry-over. Its rear section (the rod) is threaded into and then headed permanently to a cocking piece which is flared to permit easy re-cocking without opening the bolt. (The Mauser M98 had this same external re-cocking feature, but required a cartridge rim to operate.) While at the time considered useful in the event of frequent misfires, the external knob approach of the Springfield both looks awkward and slows the firing pin. The striker piece itself is a short part with a series of grooves forming a labyrinth to retard gas blowback into the bolt interior.

The rod and striker connect by a mortise and tenon joint which in turn is secured by the mainspring sleeve. The idea was to simplify replacement of a broken or damaged striker point, but it turned out to be one of those things that works better on paper than in practice. The jointed feature itself creates far more breakage problems than ever existed with the simple and sturdy Mauser-type one-piece designs.

The joint also significantly cushions the firing pin blow. There is a .005 in. take-up, and the cushioned portion—the cocking piece and rod—makes up about 80% of the total impacting mass. This, combined as it is with a very slow lock time caused primarily by the weight of the whole assembly and its long travel, adds up to one of the poorer ignition systems around.

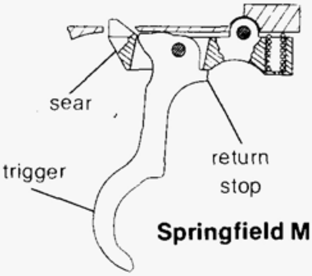
In preparing National Match and International Match rifles over the years, the Army, as might be expected, did a good deal of experimenting with the Springfield lock. Efforts varied from a headless cocking piece on an otherwise standard firing pin (which is now more or less identified as the National Match striker), to duraluminum firing pins with shortened fall, to the Garand "Super-Speed" firing mechanism (U.S. Patent 1,780,521 issued Nov. 4, 1930 [J.C. Garand]) with which International Match rifles were fitted. Lock time of the various aluminum-alloy Springfield firing pins, based on tests by R. H. Kent at the Aberdeen Proving Ground, varied from about 3 to almost 5 ms. depending on their exact configuration and whether they had steel points. Lock time for Garand's "Super-Speed" firing pin was claimed to be 2.2 ms., based on measurements at Springfield Armory using a wire and rotating smoked disc.


cocking piece
dry-fire stop
rod
firing pin sleeve
striker
knob
cam nose
sear notch

Springfield M1903, firing pin assembly

With the exception of several changes to the strength of the mainspring (as noted in the Summary), the issue rifle, however, despite its obvious shortcomings, was never modified, because even well before World War I it had ceased to receive much official design attention. Most engineering effort was focused on the development of auto-loading weapons.

The reader may note a discrepancy in the lock-time data in the Summary of this chapter, as published figures going back many years list a 5.7 ms. lock time for the issue Springfield, originating from tests by John Garand at Springfield Armory using the above-mentioned rotating-disc setup. However, it is easily shown mathematically that a 5.7 ms. lock time is not possible with any of the issue mainsprings used over the years. In fact, a mainspring with a pre-load of almost 23 lb. would be required.


sear
trigger
return stop

Springfield M1903, trigger assembly

More sophisticated tests at the Aberdeen Proving Ground using an oscillograph camera system measured a 6.8 ms. lock time with the original mainspring. Also, measurements made in recent years at Remington's Ilion laboratory using very advanced oscilloscope equipment, found lock time in the issue World War II Springfield to be 8 ms. Both of these latter results confirm very well the accuracy of the computations used in this book.

SUMMARY

The M1903 was—from a design viewpoint—a not particularly successful Mauser derivation. One design handicap was a need to make changes to avoid infringement of Mauser patents. For this, the designers naturally turned to the then current U.S. arm, the Model 1898 Krag. Few of the features carried over from the Krag proved to be good choices. And ironically, the U.S. ended up paying the Mauser organization a royalty anyway.

Without question, the Springfield rifle has an excellent reputation. Its success and prestige, however, came more from the .30-06 cartridge and the high quality of workmanship applied at the government arsenals than the basic features of the action itself, which over the years proved, for the most part, inferior to those of the parent Mauser.

Because of an insufficient number of rifles available, the M1903 was superseded by the U.S. Model 1917 as the U.S. Service Rifle in World War I. Following the war, and prior to its reinstatement, there was a great deal of discussion about improving several of its features which proved wanting during combat (primarily the rear sight and the shape of the bolt handle). No modifications occurred, however, and the Springfield rifle remained basically unchanged until Remington began modernizing some of its features from a production process standpoint during World War II.

The following summarizes the strong and weak points of the M1903 action:

Strong points:

1. Mauser-type extractor.
2. Smooth and positive operation.
3. Positive and controlled ejector.
4. Direct-acting safety.

Weak points:

1. Weak breech and gas handling.
2. Weak and spongy firing pin.

3. Slow lock time.
4. Inconvenient floorplate design.
5. Bolt-handle shape and safety limiting scope placement.
6. Direct-pull trigger.

SPRINGFIELD M1903

Dimensions

OPERATING

Extraction: set-back—.15 in.
leverage—9.75 to 1

Chambering: cam-forward—.16 in.
leverage—9.25 to 1

Bolt rotation—90°

Bolt travel—4.54 in.

Operating forces: bolt lift—6.25 lb.
bolt turndown—1.5 lb.

Cock-on-opening: .610 in.
mainspring compression
proportioned as follows:
opening—.518 in.
closing—.089 in.
trigger pull—.003 in.

IGNITION

Firing pin travel: at impact—.546 in.
dry-fired—.610 in.

	1903–1936 mainspring	1936–1942 mainspring	1942 mainspring	National Match
Lock time (ms.)	6.5	6.1	7.6	5.5
Impact velocity (ft./sec.)	14.3	15.2	12.2	16.8
energy (in.-oz.)	133.1	149.7	97.5	149.7
impulse (oz.-sec.)	1.55	1.64	1.33	1.48

Striker/firing pin hole diameters—.074 in./.082 in.

RECEIVER

Overall length—8.59 in.

Length of loading/ejection port—3.15 in.

Ring diameter—1.305 in.

Barrel/receiver threads: designation—1.040-10 (square form)
engagement—.50 in. (5 threads)

Recoil lug: width—1.07 in.
height—.36 in.
bearing area—.38 sq. in.
clearance from magazine—.93 in.

Guard screws: front—¼ x 25
rear—¼ x 25

Scope mounting provisions—none

BOLT

Lug shear area—.348 sq. in.

Lug bearing area—.075 sq. in.

Bolt diameter—.697 in.

Lug heights: left (top)—.149 in.
right (bottom)—.114 in.

Bolt face: type—semi-recessed
depth—.045 in.

MAGAZINE

Length—3.40 in.

Depth: front—1.92 in.
rear—2.11 in.

Capacity—5

WEIGHT

Receiver group—17.8 oz.

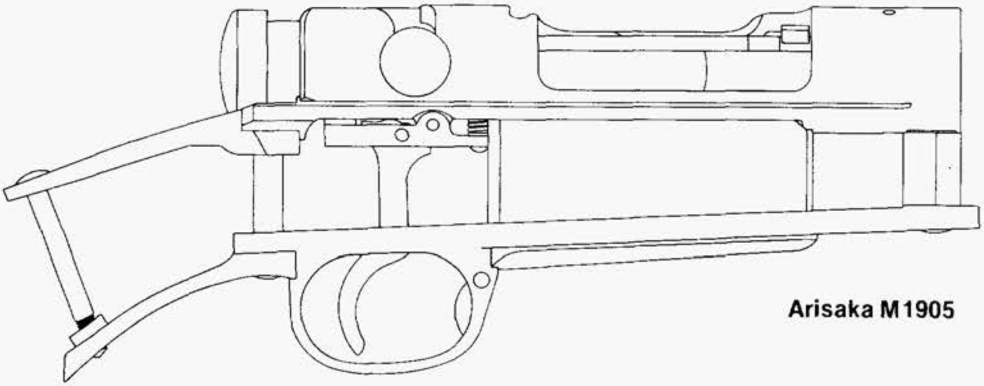
Bolt group—16.0 oz.

Magazine/floorplate group—10.5 oz.

Total action weight—44.3 oz.

3

Arisaka M1905

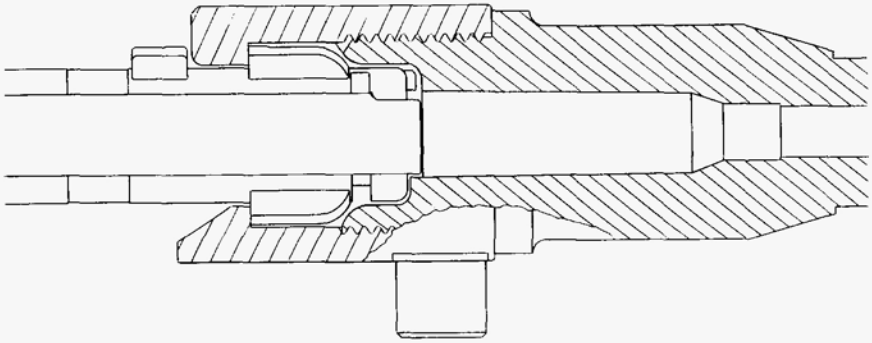


Arisaka M1905

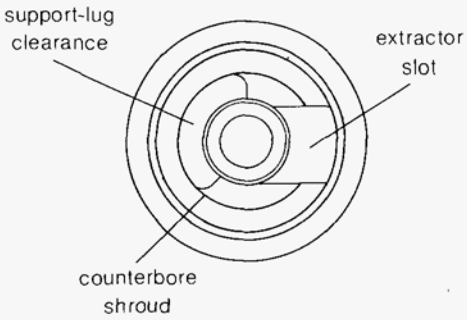
The Arisaka M1905 (officially designated Type 38 based on its adoption in the 38th year of the reign of Emperor Meiji) was Japan's version of the Mauser bolt rifle. Like many military arms, it evolved under the supervision of a commission, in this case headed by Colonel Nariaka Arisaka, superintendent of Tokyo Arsenal. The rifle, in combination with an efficient 6.5mm semi-rimmed cartridge, was adopted by Japan in 1905.

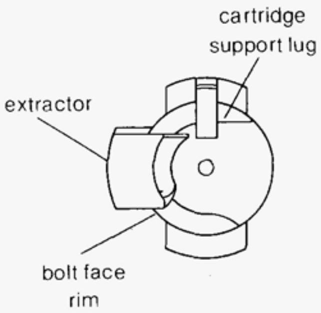
This Arisaka is more original than most Mauser derivations, but remained relatively unknown technically in the West until World War II. Tests run since then reveal it to be unusually strong, and capable of withstanding more punishment than most bolt actions.

The breech is counterbored, with a protruding bolt nose which recesses into the barrel for a strong and effective shroud. The result is functionally similar to the Mauser M98, despite the fact that Mauser's shroud ring is part of the receiver. Close examination shows that extreme care was taken to make the Arisaka breech as effective as possible, built around the Mauser feed, extraction, and ejection systems. The rear of the barrel is elaborately machined to closely match the bolt head, but in the process also creating a logistic drawback, as fitting and replacement of barrels becomes a much more involved task than with Mauser's ingeniously simple *inner-collar* system.



Arisaka M1905, breech





Arisaka M1905, bolt face

The receiver is basically cylindrical; however, unlike most modern firearms, little machining advantage is thus gained. Because of features like an elaborate integral bolt-stop housing, it remained a relatively complex machining item. Instead of an integral recoil lug, a recoil shoe slips onto a small stud under the receiver ring. This shoe has enough surface area and clearance from the magazine to eliminate the need for the cross-bolt reinforcement often applied to military stocks.

A heavy split lug positioned just behind the ejector tip blocks the left locking lug to halt bolt travel to the rear. It is an integral part of the pivoted box, and bolt release involves swinging the entire box outward. An inclined rear surface allows the bolt stop to override automatically on bolt insertion.

The M98 lock mechanism is a straight-line coil-spring-driven type, a simple and extremely effective system that goes all the way back to the Dreyse and Chassepot needle guns. Interestingly enough, Paul Mauser originally failed to grasp its virtues. His own first bolt-action rifle, the Mauser-Norris, had an elaborate and inefficient inertia firing unit driven by a cantilever mainspring formed by the rear segment of the bolt handle.

The sturdy M98 one-piece firing pin has the striker point formed at its front tip and a cocking piece fitted at the rear. It works back and forth in the hollow bolt interior under the control of the mainspring, cocking cams, and trigger. The encircling coil mainspring seats against the bolt sleeve and presses forward through a flange on the firing pin shaft, urging it to fly forward. With the lock mechanism set, this is blocked by the trigger.

The cocking piece is attached by locking lugs. This construction was first developed by Alfons Mauser (U.S. Patent 496,691 issued May 2, 1893) and then shortly after refined by Paul Mauser to the six-lug pattern applied to the M98 (U.S. Patent 499,328 issued June 13, 1893).

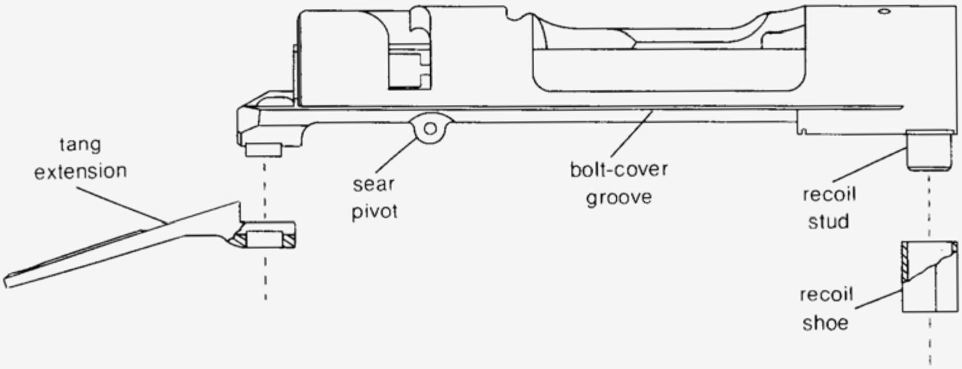
The rearmost set of lugs are slightly oversize to assure correct assembly, and thus correct firing pin protrusion, as the cocking piece controls dry firing. These heavy lugs provide ample strength to absorb the repeated impact of striker fall as well as prevent the cocking piece from coming adrift in the event of a severe gas blowback. Yet the joint has linear play (about .005 in.), introducing some cushioning to the firing pin blow. The cushioned mass (cocking piece) constitutes about 25% of the total impacting mass.

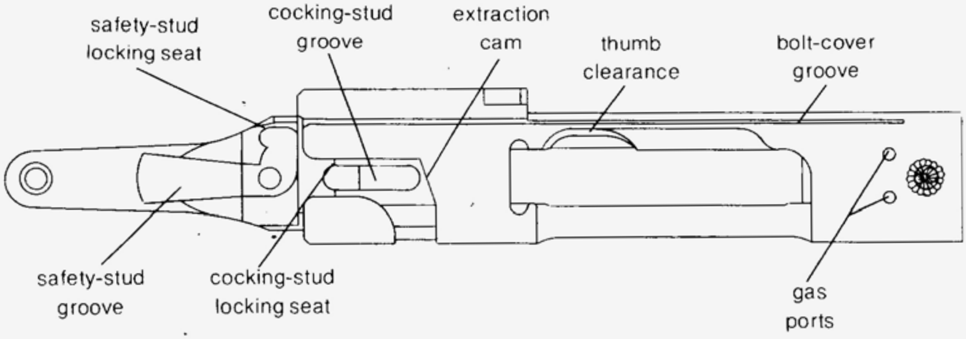
Flats milled into the firing pin shaft prevent turning in a similarly shaped opening broached through the non-rotating bolt sleeve. The cocking piece is also guided in a non-turning manner. Thus the parts can freely slide back and forth, but are indexed against turning free of each other. A rib under the cocking piece works in a groove in the receiver tang to engage the trigger. The rib extends further rearward than in earlier Mauser designs, in order to provide steadier guiding and help block dirt from the working surfaces (U.S. Patent 590,271 issued Sept. 21, 1897).

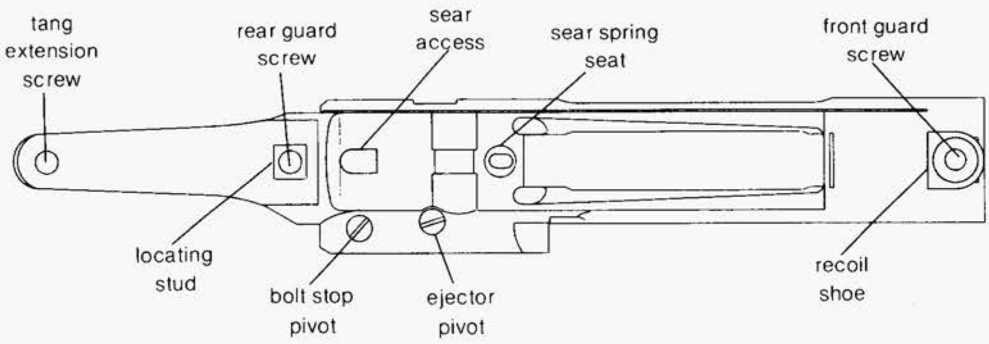
The firing pin assembly weighs about 3 oz., slightly on the heavy side compared to some modern designs. Yet Mauser's patented bolt sleeve idea did permit it to be much lighter than previous configurations with the huge external cocking pieces. The firing pin assemblies in the Mauser Model 1871, Commission M88, and Mannlicher, for example, weighed around 6 ounces.

The Arisaka has a solid bridge, yet with the portion behind the bolt-handle notch extending up to form a bolt-handle slot typical of split-bridge types. This aids bolt support, but certainly not appearance. On the left side the ejector/bolt stop box is machined integrally (rather than simply hinging to the receiver as is usually seen) and, at the front of the bridge, clip slots and a thumb clearance form a Mauserlike clip charging system.

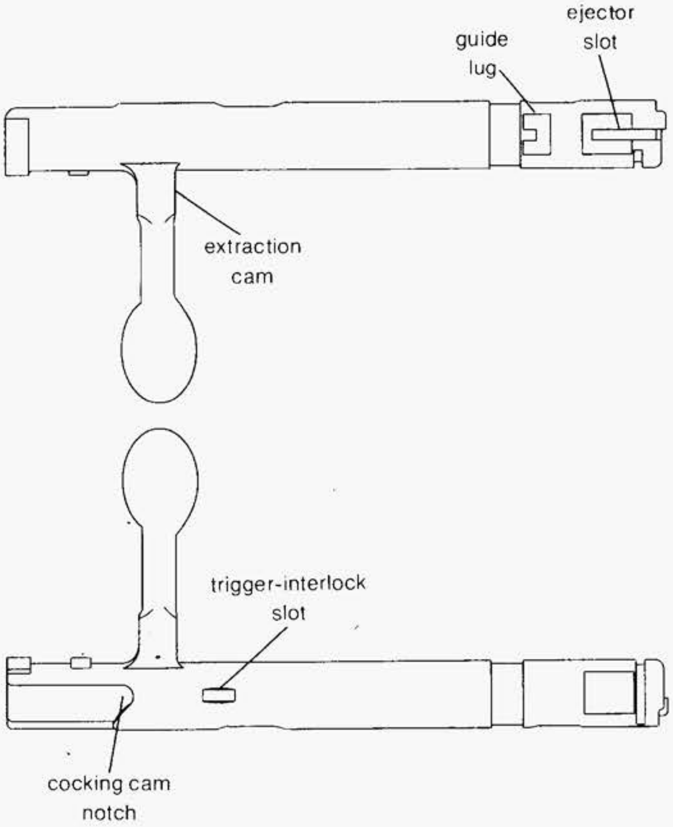
The receiver sides are grooved for a protective sheet-metal cover which cycles back and forth with the bolt. Finally, perhaps the most unique aspect of the receiver is a separate tang, cooperating with a similar unit behind the trigger guard to clamp and strengthen the stock and pistol grip.

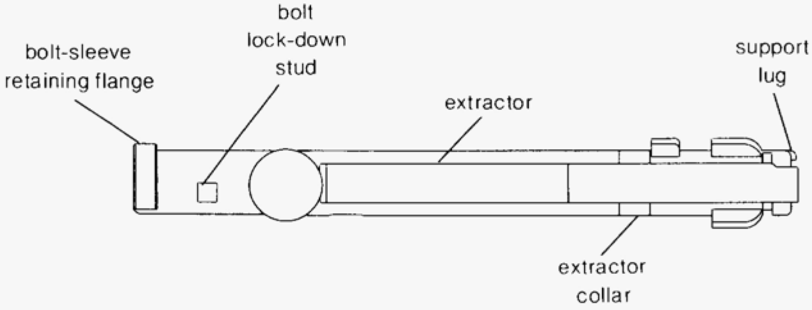

tang extension
sear pivot
bolt-cover groove
recoil stud
recoil shoe

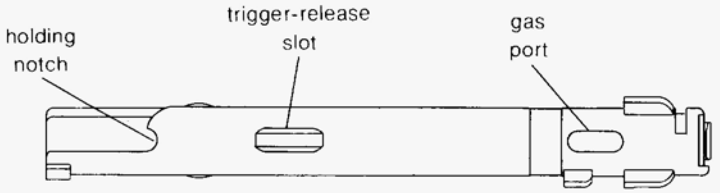

safety-stud locking seat
cocking-stud groove
extraction cam
thumb clearance
bolt-cover groove
safety-stud groove
cocking-stud locking seat
gas ports

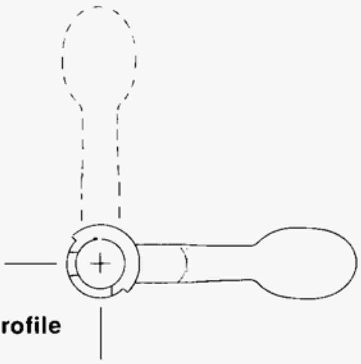

tang extension screw
rear guard screw
sear access
sear spring seat
front guard screw
locating stud
bolt stop pivot
ejector pivot
recoil shoe

The one-piece forged bolt has a straight handle with a melon-shaped grasping knob. As in the Mauser, the bolt-face rim is cut away to allow cartridges to feed directly under the extractor, and a small raised segment opposite the extractor supports the cartridge during the opening cycle.


ejector slot
guide lug
extraction cam
trigger-interlock slot
cocking cam notch


bolt lock-down stud
bolt-sleeve retaining flange
support lug
extractor
extractor collar


trigger-release slot
holding notch
gas port



Arisaka M1905, bolt-handle profile

While some early literature in this country passed the Arisaka off as a crudely made, weak firearm, it is now known to be one of the strongest of the military Mauser-type bolt actions. Its locking system is massive, particularly considering the moderate intensity of its 6.5mm cartridge, and the Japanese built in an impressive safety factor.

The Arisaka locking lugs are about the same width as the Mauser's, but are longer, giving almost 40% greater shear area. They are shallow, but the lack of ejector-slot penetration and a greater turndown proportioned to locking results in a similar advantage in bearing strength. There are only two locking lugs. The third lug on the bolt head has other functions, and does not lock into the receiver. A back-up system, however, does exist at the rear, formed by the heavy bolt-handle root.

The bolt is well guided. Supplementing the locking lugs, the bridge slot closely supports the bolt handle root to prevent a jump as the right locking lug clears the receiver ring. The extra bolt-head lug also helps. On opening it distributes support along the bolt length, while during the closing cycle, its spacing allows it to take up the slack as the left lug passes under the clip-charging thumb cut.

The extractor is a heavy Mauser type, gripping almost one-quarter of the case rim. Its tongue is undercut as in the Mauser M98, preventing slippage during extraction. On closing, however, the undercuts disengage to allow the extractor to cam easily over a cartridge rim when necessary.

The magazine is a top-loading staggered-column type, with a reinforced sheet metal cartridge box. Underneath, the trigger guard/floorplate frame is one piece, with a bushed guard screw fitted at each end. Just behind the trigger bow, a separate lower tang extends rearward to clamp and reinforce the stock. The floorplate is the usual military drop-off type, although released in this case by a serrated button of the type found in many sporting rifles.

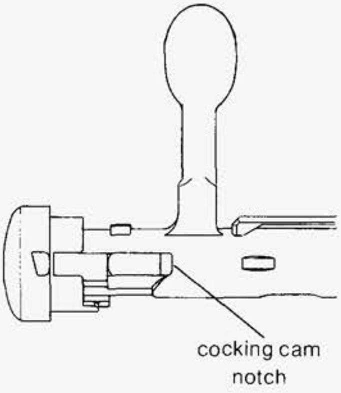
The shrouded bolt head makes the Arisaka breech a primary gas-protection feature. On top of the receiver ring are two 3mm ports which take off from a common point above the ejector slot of the locked bolt. Each angles 45° to the side, exiting at opposite sides of centerline. These combine with a 1.5mm port leading from the firing pin hole to the ejector slot to form a direct, if small, gas-escape circuit in case of a pierced primer.

Gas escaping rearward basically has two paths—through the hollow bolt interior and along the lug raceways. That entering the firing pin hole is released into the left raceway by a large 5 x 14mm slot in the bolt head. Any remaining flow, plus any tendency of the striker to drive rearward, is opposed by the solid bolt sleeve.

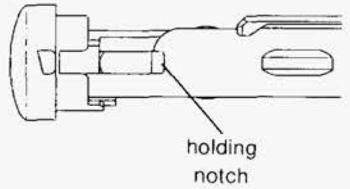
Gas handling along the bolt exterior is similar to that in the Mauser M98. The thumb cut in the left receiver wall clears pressure in the left raceway, while the bolt sleeve effectively flanges off the bridge.

Like the British, the Arisaka commission chose a *cock-on-closing* cam system in order to assure a strong extraction cycle, and the M1905 extraction cams are extremely effective, giving a .11 in. set-back at 11 to 1 leverage. The actual working surfaces resemble the Mauser's, with the bolt-handle root engaging an incline milled into the roof of the bridge.

Instead of being cut directly on the bolt rim, the cocking cam notch is located about an inch forward due to the forward-mounted striker. This cam notch is actually normal-sized, but because the holding notch is so deep (almost 1/10 in.), the net effect during opening is to little more than retract the striker point. Like the U.S. Enfield, this deep holding notch indexes the



Uncocked



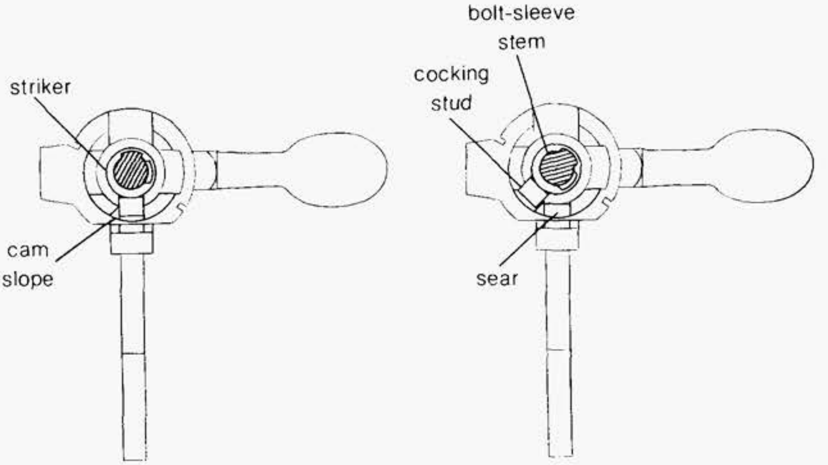
Cocked

bolt group in a very positive manner, but at the same time wastes much of the work of the cocking system.

During closing, the bolt lugs cam into the receiver ring to draw the bolt forward into battery position. The *cock-on-closing* system, however, leaves too much mainspring compression for the closing cycle and thus a considerable length of bolt travel is directly against the mainspring. Many consider this press-forward phase an awkward procedure. Not only does it fail to utilize fully the potential power of the cams, but it also tends to push the rifle from the shoulder during closing.

The unit capping off the rear of the Arisaka bolt is quite un-Mauserlike, and usually given a name other than bolt sleeve. However, we will continue with that term here. It is a single part combining the usual bolt-sleeve functions of supporting the mainspring and closing off the bolt with that of a safety and bolt lock. In addition, it is the key in a clever system of interlocks.

Physically, it comprises a hollow cap with a center stem projecting forward as the mainspring purchase. A skirt portion also extends forward and has an internal flange for attachment to the bolt. A small stud on the stem engages a series of grooves inside the striker to assure correct assembly and prevent inadvertent disengagement. Two lengthwise grooves are spaced one-quarter turn apart, and cross-connected by a lateral channel. During assembly of the firing unit, the striker must be aligned so that the stud can enter the first groove. When the bolt sleeve is pressed forward, the lateral channel allows a 90° turn to engage the skirt flange onto the bolt rim. The second groove then allows the bolt sleeve to snap back and lock onto the bolt. The stud then remains in this second groove to key the bolt sleeve and striker together.



Fire position,
striker aligned for firing

Safe position,
striker rotated out of firing position

Arisaka M1905, operation of safety

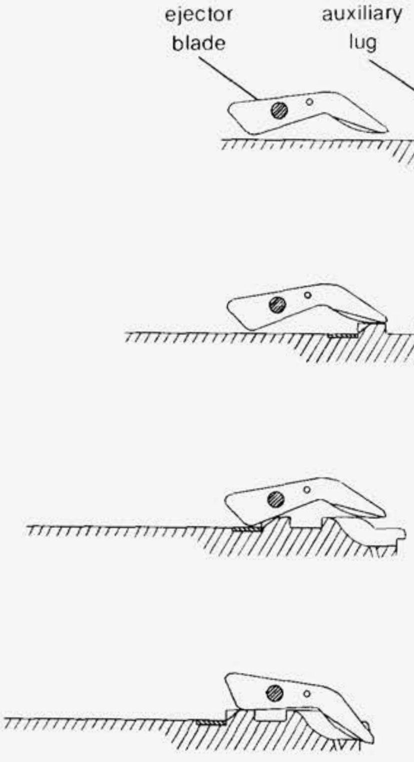
Another stud on the bolt sleeve, this one on the outer periphery of the cap, works in a special groove in the tang and receiver to align the bolt sleeve. It also forms part of the safety linkage described next.

Operation of the Arisaka safety is unique and sometimes misunderstood. Basically, instead of simply retracting the striker as the Mauser safety does, the cocking stud is shifted to the side and locked directly into the receiver.

The system centers around the bolt sleeve. The safety is set by pressing the bolt sleeve forward, rotating it 45° clockwise, and releasing. This leads the outer stud on its periphery into a notch in the receiver floor, where it is locked by mainspring tension. More important, the same motion rotates the striker so that the cocking stud is moved away from the sear and over behind a heavy locking shoulder on the receiver floor. The striker is thus turned out of alignment for firing and locked directly into the receiver.

The *safe* position also positions a flange within the bolt-sleeve skirt over a small stud on the bolt. Thus, with the bolt sleeve so positioned, both the bolt and striker are locked into the receiver by the bolt sleeve, which in turn is locked in position by the mainspring.

It is remarkable that so few parts can accomplish so many functions and form so many interrelationships to assure nothing is assembled wrong or occurs out of phase. This careful series of interlocks was devised because the previous Japanese service rifle adopted under Colonel Arisaka's supervision, the M1897 (Type 30), was subject to incorrect field assembly, and like the Canadian Ross, as a consequence acquired a reputation for being potentially dangerous.



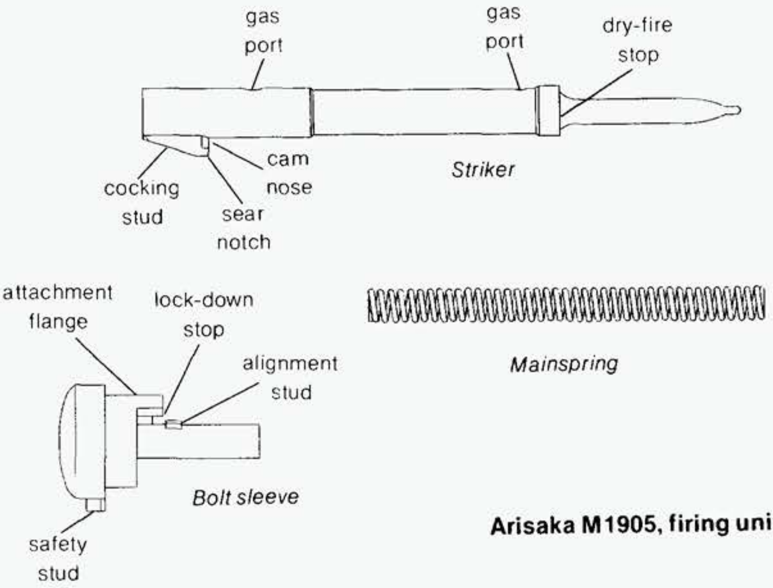
Arisaka M1905, operation of ejector

The ejector is impact-actuated as in the Springfield, but for a different reason. In the M1903 it simply lightened bolt movement by eliminating spring tension. In the Arisaka it sequences movement of the blade to allow a solid rear face on the left locking lug.

This sequencing is accomplished by the third bolt-head lug, which is slotted at the rear to clear and position the ejector tip. When it then contacts the ejector heel, the tip is cammed inward with just enough delay to avoid striking the left locking lug.

This extra lug also controls bolt stroke, thus saving wear and tear on the left locking lug. It contacts a heavy flange pivoted into the left raceway and retained in blocking position by the outer wall of the ejector/bolt stop box. Because of the thickness of this wall, bolt removal is no small task in the Arisaka.

Instead of a conventional striker mechanism, with a long rod-like firing pin extending the length of the bolt and fitted at the rear with a cocking piece, the Arisaka has a hollow piston-like firing pin, driven from the rear. A small integral cocking stud performs the usual functions of the cocking piece. This construction offers several advantages: The striker is compact


gas
port
gas
port
dry-fire
stop
cam
nose
cocking
stud
sear
notch
Striker
attachment
flange
lock-down
stop
alignment
stud
safety
stud
Bolt sleeve
Mainspring

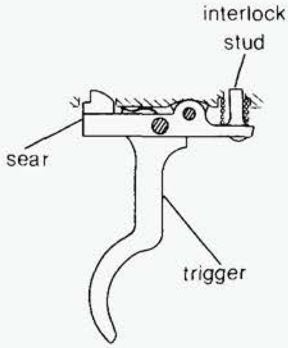
Arisaka M1905, firing unit

and well guided; field stripping is simplified; the application of a shrouded bolt sleeve is easier; finally, the mainspring is protected from overcompression and from escaping gas.

Behind the sear, the cocking stud has no guide groove in the receiver floor, and thus the striker is not aligned directly. This is necessary to allow it to rotate into safety position. Alignment prior to firing is controlled indirectly by the linkage between the striker, bolt sleeve, and receiver.

Another unique feature is a small striker tip which permits a firing pin hole of about 30% smaller area than in a Mauser or Springfield. This adds strength to the action by both lessening the likelihood of blanked primers and restricting gas blowback in case a primer does fail.

The Arisaka trigger is a standard double-draw type, but fitted with an interlock system like that in the Mauser Model 1893 and later used in the Enfield P14 and M1917. This interlock functions to prevent misfires by blocking the trigger when bolt lift exceeds about 5°.


interlock
stud
sear
trigger

Arisaka M1905, trigger assembly

SUMMARY

The Arisaka is neither a highly regarded nor popular action in this country, mainly because it does not readily adopt to an attractive sporting rifle and because it cocks on closing. Its virtues, however, include strength and ease of disassembly. The following summarizes the strong and weak points:

Strong points:

1. Shroud-type breech.
2. Mauser-type extractor.
3. Strong locking pattern.
4. Positive and controlled ejector.
5. Direct-acting safety.
6. Easy field stripping.

Weak points:

1. Cock-on-closing.
2. Difficult bolt-stop release.
3. Direct-pull trigger.
4. Difficult safety actuation.
5. Bolt handle shape limiting scope placement.
6. Drop-off floorplate.

ARISAKA M1905

Dimensions

OPERATING

Extraction: set-back—.11 in.
leverage—11 to 1

Chambering: cam-forward—.14 in.
leverage—9 to 1

Bolt rotation—91°

Bolt travel—4.37 in.

Operating forces: bolt lift—3.5 lb.
press-forward—21 lb.
bolt turndown—4 lb.

Force to close bolt when single-loading—4.5 lb.

Cock-on-closing: .573 in.
mainspring compression
proportioned as follows:
  opening—.120 in.
  press-forward—.294 in.
  closing—.151 in.
  trigger pull—.008 in.

IGNITION

Firing pin travel: at impact—.494 in.
  dry-fired—.573 in.

Lock time—5.4 ms.
Impact velocity—15.4 ft./sec.
  energy—96.5 in.-oz.
  impulse—1.05 oz.-sec.

Striker/firing pin hole diameters—.067 in./.070 in.

RECEIVER

Overall length—7.48 in. (9.98 in. with tang extension)

Length of loading/ejection port—2.85 in.

Ring diameter—1.335 in.

Barrel/receiver threads: designation—M26x1.75 (metric)
  engagement—.55 in. (8 threads)

Recoil shoe: width—.59 in.
  height—.74 in.
  bearing area—.44 sq. in.
  clearance from magazine—.94 in.

Guard screws (metric): front—M6x.9
  rear—M6x.9

Scope mounting provisions—none

BOLT

Lug shear area—.443 sq. in.
Lug bearing area—.080 sq. in.
Bolt diameter—.705 in.
Lug diameter—.942 in.

Bolt face: type—semi-recessed
depth—.051 in.

MAGAZINE

Length—3.11 in.

Depth: front—1.89 in.
rear—2.07 in.

Capacity—5

WEIGHT

Receiver group—19.5 oz.

Bolt group—14.0 oz.

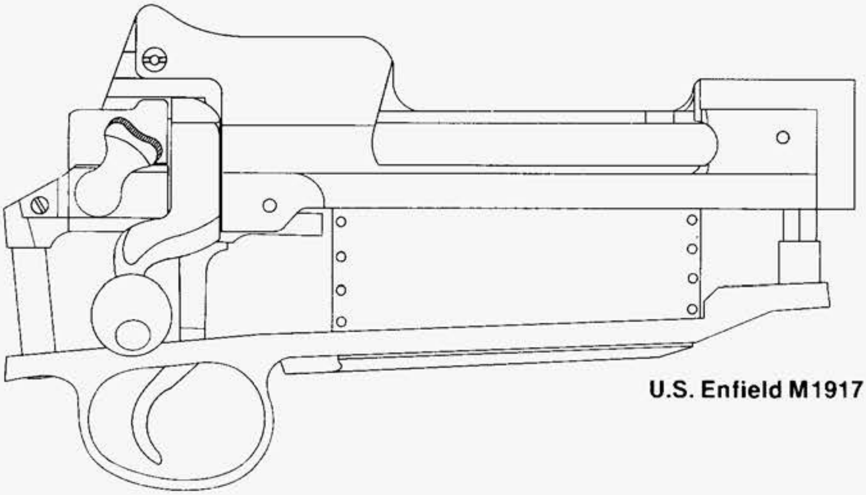
Bolt cover—2.4 oz.

Magazine/floorplate group—13.0 oz.

Total action weight—48.9 oz.

4

U.S. Enfield M1917



U.S. Enfield M1917

The U.S. Enfield started as the Pattern 1913, Britain's version of the Mauser. Developed at the Enfield Arsenal in conjunction with a .276 rimless cartridge, this rifle and cartridge were intended ultimately to replace the Lee-Enfield and .303 cartridge combination, although neither ever did.

About a thousand P-13 rifles were manufactured in .276 for evaluation. Approaching war, however, forced abandonment of the experimental cartridge, and the new rifle was modified to .303 caliber and redesignated the Pattern 1914. Britain contracted with three large American arms companies—Winchester, Remington, and Remington of Delaware (Eddystone)—to supply P-14 rifles. Between 1914 and 1917, approximately one million were made.

When the U.S. entered World War I, we were far short of M1903 rifles and lacked the production facilities to turn them out in adequate numbers.

Since the above commercial firms were just completing their British contracts, the Army had these already tooled-up factories modify the P-14 design to handle the .30-06 Springfield cartridge and standardize dimensions.

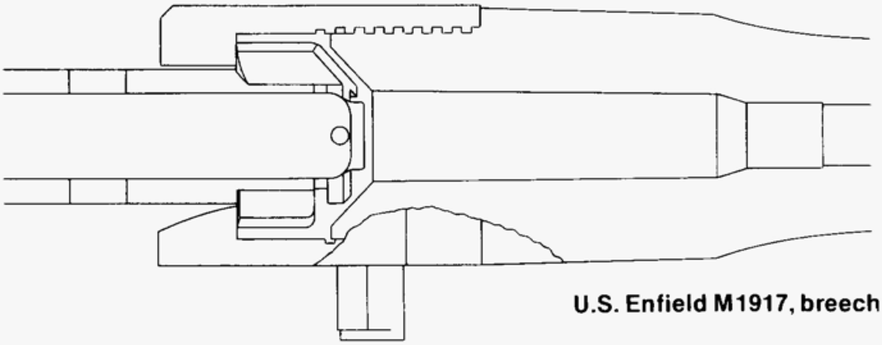
Not only had P-14 parts from the three factories not been interchangeable, but rifles at each plant required hand-fitting. By improving tolerances to permit true assembly-line production, the cost of each rifle dropped from $42 under the British contracts to $26, saving the U.S. Government many millions of dollars.

This modified rifle was designated "U.S. Rifle, Cal. .30, Model of 1917," and between August 1917 and November 1918, over two million were built. In comparison, during this same wartime period, production of M1903s at Springfield Armory and Rock Island Arsenal combined totaled less than 300,000.

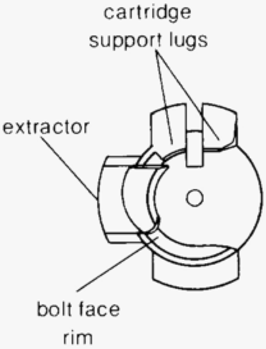
Getting back to the original development at Enfield, work started in 1910 and the rifle evolved basically as a blend of features from the Mauser M98, Springfield M1903, and Lee-Enfield, as shown in the following breakdown:

- Features derived from the Mauser M98:
  - One-piece bolt with front locking lugs.
  - Staggered-column, detachable floorplate magazine.
  - External, non-rotary extractor.
  - Lugged firing pin.
  - Combined ejector and bolt stop.
- Features derived from the Springfield M1903:
  - Cone breech (for the P-13).
  - Receiver shape (except bridge).
  - Extraction cams.
  - Gas-handling layout.
- Features derived from the Lee-Enfield:
  - Angled locking faces.
  - Rocker-action safety.
  - Cock-on-closing.
- Miscellaneous features:
  - Bolt-handle safety lug (like the 1895 Mauser).
  - Trigger interlock (like the 1893 Mauser).
  - Bridge aperture sight/low-profile bolt handle.

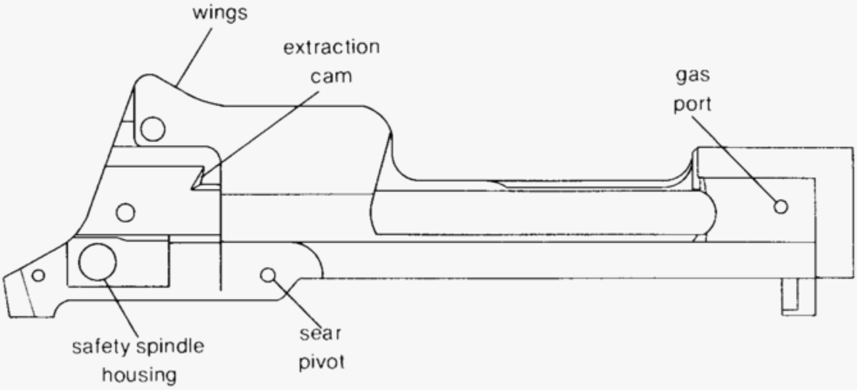
The breech requires little description, as it directly copies the M1903 Springfield. Except for the top of the bridge, the same applies to the receiver. It is a nickel-steel forging, and has the same recoil lug, short rear tang, and reinforcing pad on the receiver ring. Its loading/ejection port is about 1/2 in. longer than either the Springfield or Mauser, making it much-used for conversion to the long belted-head cartridges.

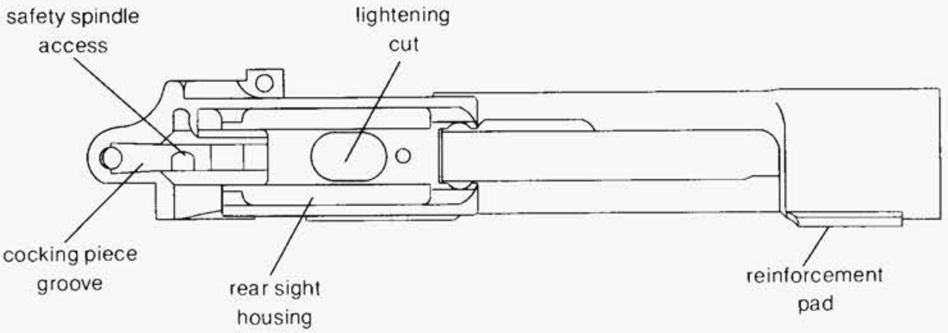


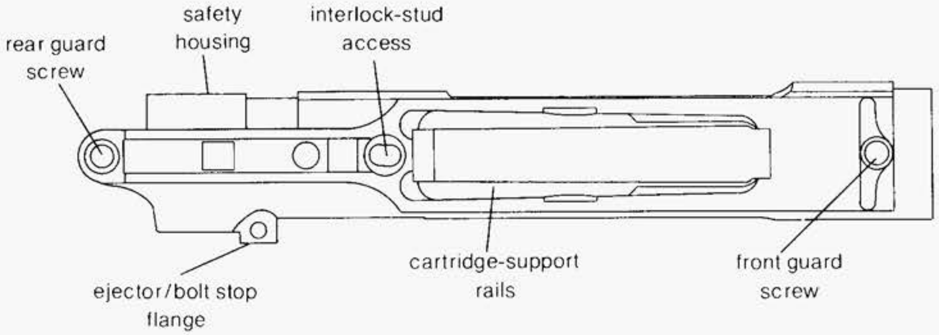
U.S. Enfield M1917, breech


cartridge support lugs
extractor
bolt face rim

U.S. Enfield M1917, bolt face


wings
extraction cam
gas port
safety spindle housing
sear pivot


safety spindle access
lightening cut
cocking piece groove
rear sight housing
reinforcement pad

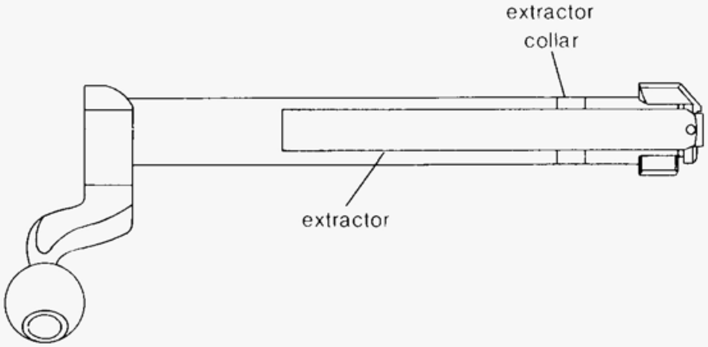

rear guard screw
safety housing
interlock-stud access
ejector/bolt stop flange
cartridge-support rails
front guard screw

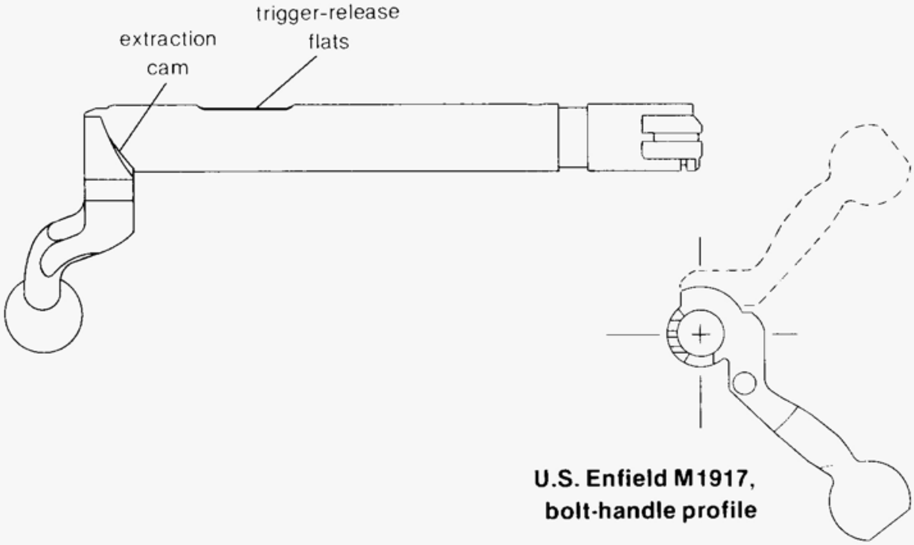
This *magnum* length originates from the fact that the British originally intended to adopt a cartridge very similar to the .280 Ross, which was about equivalent in size to the later H&H magnums. Because of Britain's cordite powder, however, the .276 ended up much smaller, shorter, in fact, than the .30-06 Springfield cartridge. When the .276 project was shelved and the P-13 modified otherwise for the .303 British cartridge in preparation for mass production abroad, the receiver wasn't shortened. Instead, the magazine was simply blocked. A couple of years later when the U.S. in turn adopted this action—this time for the .30-06—the production lines were already set up and the wartime schedules ruled out any such changes.

An aperture rear sight is built into the Enfield receiver bridge, giving a longer sight radius and easier adjustments than the usual barrel-mounted rear sight. Massive protective ears or wings accompany it. Despite their value in the military weapon, they are obstacles in sporterizing the action, adding considerable excess weight and bulk. In addition to having to mill these off, another problem is a weight-saving cavity milled into Winchester and some Eddystone versions which must be filled in to achieve an attractive bridge contour.

Two guard screws are used, one under the recoil lug and the other under the rear tang and angling slightly forward as in the M1903. Both screws are bushed to prevent springing the receiver or floorplate. The front bushing also registers with the receiver and floorplate for alignment. The recoil and bedding patterns basically copy those of the Springfield.

The bolt is a nickel-steel forging. It lacks the Mauser and Springfield safety lug, instead using the root of the bolt handle for this purpose, and any special guide rib or flange. The most distinctive feature is a *dog-leg* handle which, while awkward-looking, does give an efficient grip, particularly helpful since the bolt must be pressed closed against mainspring pressure. Less noticeable, but more significant, is the bolt handle's *low-profile* shape, originally incorporated to clear the aperture sight superstructure, and now (by happy accident) making it suitable without modification for low-mounted scopes.





U.S. Enfield M1917, bolt-handle profile

The Enfield's strength, particularly as compared to the Springfield, is often the subject of analysis. Some hold that it is stronger, others that it is only heavier and clumsier. Actually, with their funnel-type breeches and ineffective gas handling, neither is exceptionally strong. Purely from the standpoint of lug size, however, the M1917 is quite strong and has about a 20% edge in shear and bearing areas.

The locking lugs and receiver-ring seats are not square to the receiver axis, but are cut on a lead of about 4°. This technically gives the Enfield an *interrupted-thread* locking system, something often mistakenly attributed to multiple-lug actions like the Weatherby Mark V and Remington Model 788, probably because of a superficial resemblance to some early multiple-lug actions like the Newton and Ross which did have true interrupted-thread, artillery-piece locking systems.

The angled locking faces of the M1917 were carryovers from the Lee-Enfield, based on the work of the American designer James Paris Lee. This rifle had a non-rotating bolt head secured by right-hand threads. A locking-system lead was thus necessary to prevent the bolt head from backing off the cartridge during the final closing motion and conversely to prevent jamming on opening.

With the integral bolt head of the M1917, this lead or helix angle gives a slight cam-forward action during closing. Thus it is doubly significant to fully close the Enfield bolt before firing, to not only engage the locking lugs, but also position the bolt for proper headspace.

Once closed, the angled faces are not a factor in the bolt's lockup. The 4° angle is only about half the so-called *angle of repose*, even with smooth and well-lubricated surfaces, and thus no danger exists of the bolt unlocking or *overhauling* under cartridge thrust. When the bolt handle is raised, however, the locking faces immediately clear contact to reduce friction and aid the extraction cycle, rather than dragging across each other during the entire unlocking phase as is normal with square lugs.

The externally mounted extractor is similar to the Mauser's, except the face is beveled to engage a chambered round readily and thus allow direct cartridge loading as well as magazine feed.

The magazine is a top-loading staggered-column type, with a separate cartridge box of riveted construction. While of similar working length to the Mauser and Springfield, the magazine well in the Enfield receiver is longer, thus making possible a good deal of lengthening by simply re-working or replacing the bulky cartridge box.

The floorplate assembly is made from heavy milled steel parts, with a locking and release system like the Mauser and Springfield. The deep six-shot cartridge box causes the floorplate frame to angle down behind the front guard screw, bulging the bottom line of the stock. Like the length of the magazine well, this deep cartridge box was also something of a quirk, resulting from the hurried adaptation of the design during wartime from an experimental action to a British and then to an American service rifle. The Enfield was never intended to have a six-shot magazine, and in fact both the British and U.S. charger clips contained five cartridges. As the British P-13 and P-14 the magazine held only five cartridges, because of the size of the .276 and .303 case heads. When adapted for the smaller-diameter .30–06 cartridge, time unfortunately did not allow even the relatively minor changes in trimming the magazine depth and streamlining the bottom of the rifle.

Like the M1903, the M1917 magazine follower piece lacks an override bevel. Unlike the Springfield, however, there is no magazine cut-off and so this proved awkward for certain drill and practice functions. To remedy this, a nickel was used to jam under the rails and hold the follower down. Soon the Army issued large quantities of a sheet metal part called the *follower depressor* for the same purpose.

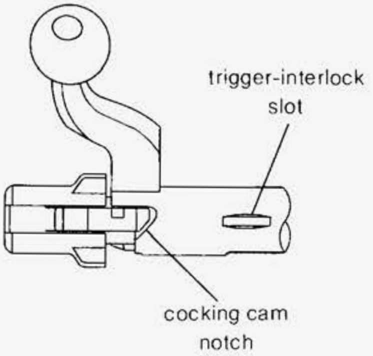
The M1917 handles escaping gas in much the same ineffective manner as the Springfield M1903. A 1/8 in. port in the receiver ring registers with a small hole in the extractor to vent the breech. The left receiver-ring wall is solid.

Internally, the bolt head is ported at the firing pin hole. Despite this, plus slots in the mainspring flange and a second larger bolt port to the rear, the Enfield firing pin is prone to gas pressure and is easily snapped rearward by a blown primer. The firing pin jams into the broached mouth of the bolt sleeve as the primary stop means. This occurs when it has been driven rearward almost an inch beyond full cock and tends to jam the lock mechanism, often requiring a sharp rap on the cocking piece to get back into operation.

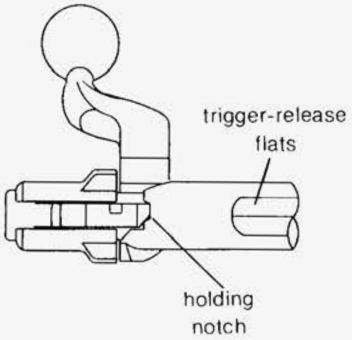
This containment of a rearward-blown firing pin contrasts with that in the M1903. Where one action is weak, the other is strong, and vice-versa. The M1903 mainspring bottoms out quickly, about 1/4 in. beyond full-cock. This is not a highly positive system, however, leaving a remote possibility of total failure. The M1917 stop means is strong and positive, but slow in acting, allowing a much greater snap-back.

Both of the bolt-head ports dump into the left raceway. This raceway, which can also receive powder gas directly from the breech, is neither effectively vented or flanged, allowing much released gas to exit directly toward the shooter's face.

While the Enfield's operating cams are like those of the M98 and M1903, mainspring compression is accomplished by a cock-on-closing system. The cocking cam is shallow and only compresses the mainspring slightly, leaving most of the work for the closing motion.



Uncocked



Cocked

Cock-on-closing was favored by the British and carried over from the Lee-Enfield. Its basic rationale goes something like this: In combat, a hot or dirty chamber makes extraction the biggest operating problem. Merely camming the striker point back far enough to clear the bolt face during opening saves maximum operating effort for extraction.

The argument would be more persuasive were this simply a matter of reproportioning between the cocking and chambering cam systems. Locking-cam displacement, however, is relatively small, and thus a shallow cocking notch leaves most of the remaining mainspring compression to be accomplished directly when pressing forward on the bolt handle, without aid of bolt-turndown leverage. (The Newton Buffalo Rifle, built in the late 1920s, was an exception. It had an ingenious, but complex, cocking system wherein 100 percent of mainspring compression occurred *with* cam assistance during turndown of the bolt handle.)

An allied problem exists. The Enfield trigger is not reset on bolt lift, and so this also occurs without cam assistance. Trigger reset isn't even noticed when done during bolt lift in a cock-on-opening action. But in the Enfield, a very annoying hesitation occurs as the spring-loaded sear is forced aside when initially pulling the bolt rearward.

Another argument used to favor cock-on-closing is that push-forward cocking is more reliable in combat, as it is less subject to being locked up or jammed by mud or grit than a cam cocking system. Also, operation has been claimed to be as fast or faster than with the cock-on-opening systems. The U.S. Army manuals did, in fact, show the M1917 Enfield having a slight advantage over the Springfield M1903 in rapid fire.

In order to reserve final bolt-lift effort exclusively for extraction, the cocking cam is narrow as well as shallow. Instead of distributing cocking effort throughout the entire quarter-turn lift, it ends a little after the midpoint, and before extraction-cam engagement. After leaving the cocking notch, therefore, the cocking piece rides a considerable distance along the bolt rim before snapping into the holding notch.

A holding notch is usually small, deep enough only to capture the cocking piece and index the bolt group. The Enfield notch, however, is .060 in. deep, releasing much of the mainspring compression started by the cocking notch. Were it not overly deep, less effort would remain for the press-forward closing phase.

The extraction cams copy the Springfield. A helix-cut cam recessed within the bridge and located down close to the bolt centerline cooperates with a sweeping flange on the bolt-handle collar.

During closing, the bolt lugs engage helical inclines leading into the receiver-ring seats to draw the bolt forward at a very powerful 12 to 1 leverage. Normally, remaining bolt turndown would simply bring the locking faces into full engagement, without further axial displacement. The angled Enfield locking faces, however, continue to slowly advance the bolt at a leverage of greater than 100 to 1.

Extra camming power is thus available to chamber home a reluctant cartridge. The question of course arises as to how useful such extra power actually is, if not matched in the extraction cycle. It can make bolt closure more positive under some circumstances, but may also allow chambering a round which won't extract. With certain obvious exceptions, it's usually better to shuck out immediately what appears to be a bad cartridge, than to risk jamming the action.

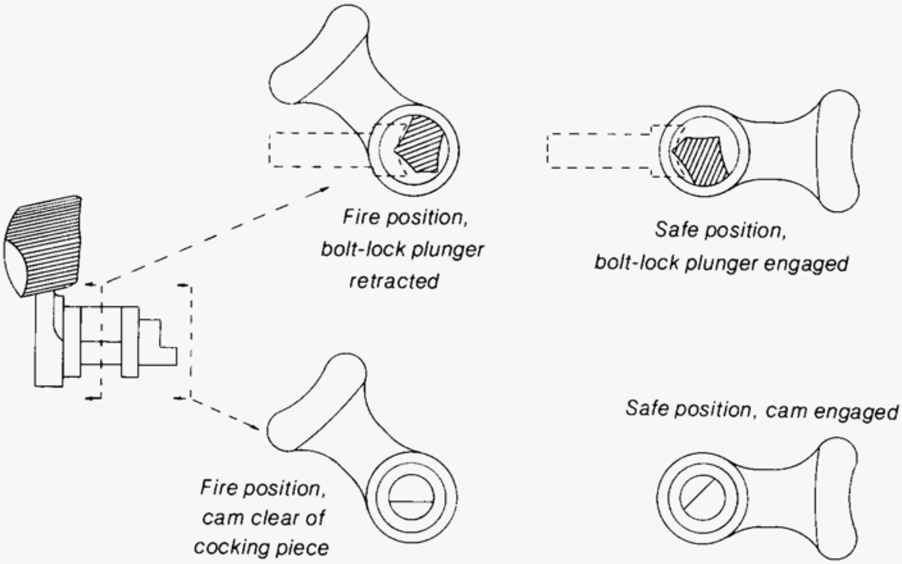
The safety is a two-position type basically patterned after that in the Lee-Enfield. A heavy thumbpiece and double-cam spindle are machined as one piece and clamped to the receiver by a small flange. In front of the spindle is a spring-loaded bolt-lock plunger.

With the thumbpiece rocked rearward, one cam enters a notch in the cocking piece to cam it rearward while the other pushes the plunger forward to lock the bolt handle.

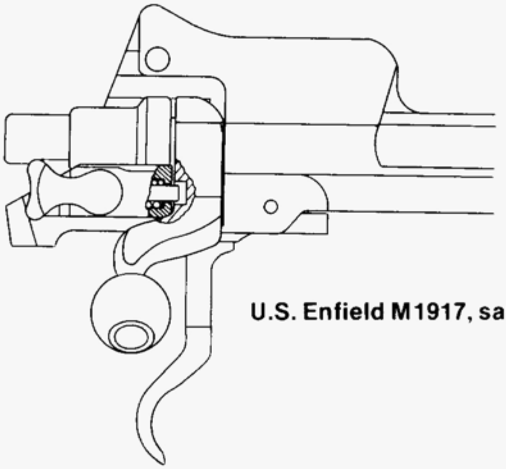
Rocked forward, the cocking piece is eased back into contact with the sear while simultaneously the locking plunger is allowed to shift back and free the bolt.

This certainly rates as one of the best bolt-action safeties ever developed, combining positive action, quick and silent operation, and compatibility with a low-mounted scope (again, the origin of this clearance was the need to avoid the aperture-sight superstructure). Being receiver-mounted, it also allows a much trimmer bolt sleeve than in either the Mauser or Springfield. Also, with only two positions, the holding notch can lock the bolt sleeve, eliminating the need for a special indexing system.

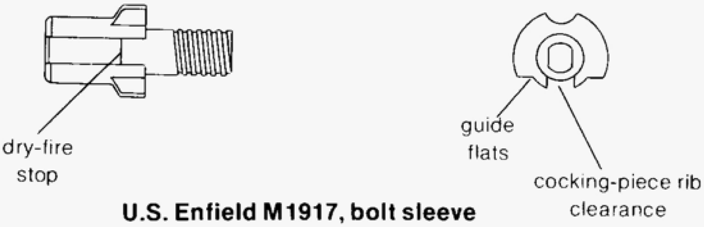
Ejection is like the Mauser, with the ejector blade sandwiched between


Fire position,
bolt-lock plunger
retracted
Safe position,
bolt-lock plunger engaged
Safe position, cam engaged
Fire position,
cam clear of
cocking piece

U.S. Enfield M1917, safety lock

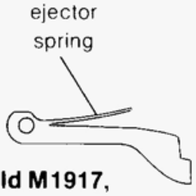


U.S. Enfield M1917, safe position


dry-fire
stop
guide
flats
cocking-piece rib
clearance

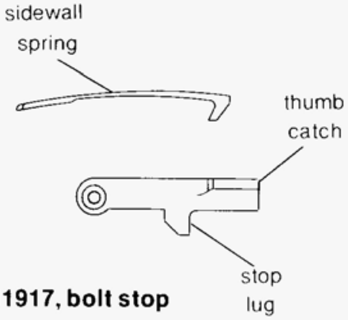
U.S. Enfield M1917, bolt sleeve

the bolt-stop lugs in a box pivoted to the bridge. The blade itself is large and sturdy, but is actuated by a very frail leaf spring peeled directly from its side. This design has a history of frequent breakage, and substitution of a coil spring has been a common gunsmithing improvement since these rifles got into the hands of civilian shooters.



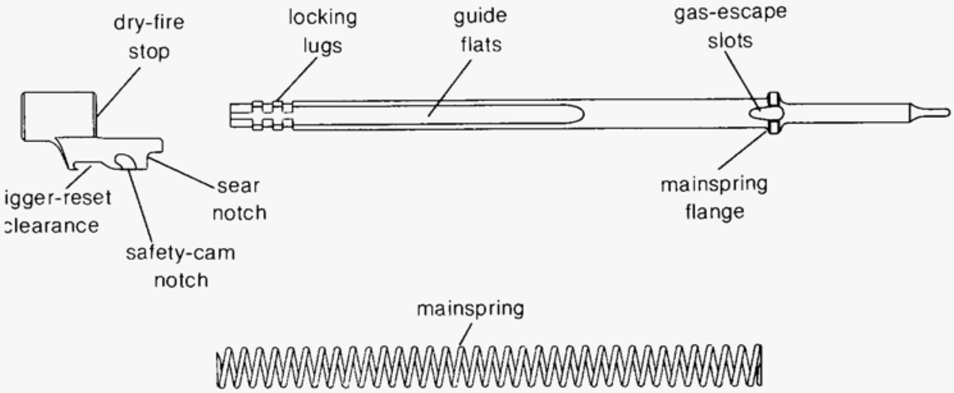
U.S. Enfield M1917, ejector

The bolt-stop lugs are an integral part of the swing-out box and are pressed inward by its outer wall like the Mauser. The Enfield assembly, however, is even bigger and harder to operate. The outer-wall spring extends to the rear, requiring a special support pad. It is way overdesigned, and sporterizing jobs trim it down by at least eliminating the rear portion.



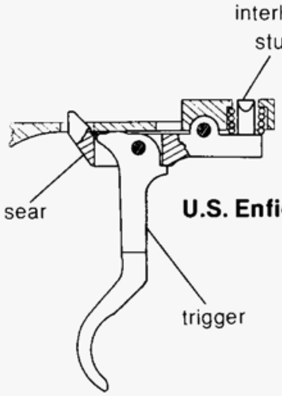
U.S. Enfield M1917, bolt stop

The firing pin is a slimmed-down version of that in the Mauser M98, except without the interlock lugs on the mainspring flange (using instead a trigger interlock as described later). Striker fall is longer than in either the Mauser or Springfield, giving a very heavy impact on the primer, about double that found in the typical modern commercial bolt action. Because of a comparatively light firing pin, however, lock time is better than might be expected. As in the Mauser, a slight play in the lugged cocking piece joint cushions the striker blow.


dry-fire stop
locking lugs
guide flats
gas-escape slots
igger-reset
learance
sear notch
safety-cam notch
mainspring flange
mainspring

U.S. Enfield M1917, firing pin assembly

The Enfield's direct-pull trigger is fitted with an interlock system copied from the Mauser Model 1893. The sear nose cannot move down to release the cocking piece unless a stud on the opposite end simultaneously rises into a narrow clearance slot in the bolt. This slot lies directly over center only when the bolt is fully closed, although, because of clearances in the parts, the system does not interfere as long as the bolt is within about 5° of full-closed.


interlock stud
sear
trigger

U.S. Enfield M1917, trigger assembly

Contrary to popular belief, the intended function is not simply to prevent ignition if the lugs are not seated, because as noted in the Mauser chapter, the bolt rim already takes care of this. The trigger interlock's value is in preventing a misfire under this circumstance. Without it, if the trigger is pulled with the bolt partly lifted, the cocking piece either catches on the bolt rim or spins the bolt closed. Either way, the resulting misfire requires a re-cocking cycle, a potentially costly error in combat. With the interlock, the raised handle is immediately apparent and can be slapped down.

The U.S. Army field manual for the M1917 stated that interlock of the firing system is only a secondary function of this stud on the sear frame, the primary function being to rise during trigger pull and lock the bolt from turning due to the reaction of the angled locking faces under the backthrust of the cartridge. This is so much nonsense, and it is unlikely that this was even a consideration when the rifle was designed in Britain. Trigger interlocks had already been used in several bolt action rifles without angled locking faces. Further, the Lee-Enfield, from which the angled faces were derived, had no such special anti-rotation scheme.

Since the trigger cycles also as the bolt is drawn back, a second clearance for the interlock is required. Rather than another slot, two flats are blended into the bolt, so as to move smoothly past the ejector blade during closing.

These flats also allow bypassing the interlock to release the striker without snapping. The bolt is worked partly forward until the flats are over the interlock stud. The trigger can then be pulled to allow the bolt to continue forward. Slowly lowering the bolt handle from this point drops the cocking piece down the cocking-cam slope. Of course exactly the same effect is possible on almost any other bolt action, which lacks the trigger interlock, by simply pressing the trigger during the entire closing cycle.

Without a bolt-sleeve mounted safety, field stripping the Enfield bolt is a little more involved than in the Mauser. The cocking piece is hooked underneath, and the official disassembly procedure, detailed in early field manuals, involved retracting the cocking piece with a length of string, while simultaneously unscrewing the bolt sleeve. Of all conceivable methods, this may be the most difficult. It is far more practical to simply jack the cocking piece back on the edge of something and lock it open with a coin.

There is, however, a third much easier method which avoids all this struggle. By engaging the safety with the bolt withdrawn, it will catch on the sear ledge on closing, forcing the cocking piece rearward far enough to expose a gap into which a coin can be placed. This was known during the First World War, and in fact many soldier's kits contained a coin earmarked for this purpose, but based on some reason now obscure, the procedure was patented during World War II (U.S. Patent 2,373,141 issued April 10, 1945 [G. H. Orloff]).

SUMMARY

Almost as many Enfields were made for the U.S. in the fifteen months of its manufacture as the total number of Springfields over a forty-year span. Because of these numbers, it became, in fact, the official service rifle of the Expeditionary Army in World War I. Yet it never really achieved the popularity or status of the Springfield. While strong and dependable, it lacked the Springfield's trim lines and refined functioning. It was relegated to reserve status following the war, although not entirely based on a functional judgment, but rather primarily because the Government did not have production and repair facilities to support it in the future years, as it did for the Springfield rifle.

As the basis for a custom sporting rifle, the Enfield had the advantage of interior dimensions which readily allowed conversion for the H&H cartridges. Following World War I, large numbers ended up in the hands of civilian shooters by way of the D.C.M. and many of the leading gunsmithing houses of the day specialized in converting these. Today, however, the amount of work involved, plus the excellent selection of factory arms suitable for magnum cartridges, makes this an impractical solution except as a hobby. The following summarizes the Enfield's strong and weak points:

Strong points:

1. Strong locking lugs.
2. Mauser-type extractor.
3. Integral bolt handle (and back-up lug).
4. Direct-acting safety.
5. Powerful extraction and chambering cams.
6. Positive and controlled ejector.
7. Low-profile bolt handle and safety.

Weak points:

1. Springfield breech and gas-handling.
2. Cock-on-closing.
3. Slow lock time.
4. Direct-pull trigger.
5. High awkward bridge.
6. Inconvenient floorplate design.
7. Awkward bolt-stop/ejector box.
8. Fragile ejector spring.
9. Excessively deep magazine.

U.S. ENFIELD M1917

Dimensions

OPERATING

Extraction: set-back—.15 in.
leverage—11 to 1

Chambering (two-phase)
1st (from cams) cam-forward—.13 in.
leverage—12 to 1
2nd (from angled locking faces) cam-forward—.02 in.
leverage—100 to 1

Bolt rotation—91°

Bolt travel—4.75 in.

Operating forces: bolt lift—2.5 lb.
press-forward—18 lb.
bolt turndown—3 lb.

Force to close bolt when single loading—7.5 lb.

Cock-on-closing; .713 in.
mainspring compression
proportioned as follows:
opening—.117 in.
press-forward—.459 in.
closing—.128 in.
trigger pull—.009 in.

IGNITION

Firing pin travel: at impact—.647 in.
dry-fired—.713 in.

Lock time—6.5 ms.

Impact velocity—16.8 ft./sec.
energy—145.5 in.-oz.
impulse—1.44 oz.-sec.

Striker/firing pin hole diameters—.076 in./.082 in.

RECEIVER

Overall length—8.85 in.

Length of loading/ejection port—3.58 in.

Ring diameter—1.355 in.

Barrel/receiver threads: designation—1 1/8–10 (square form)
engagement—.6 in. (6 threads)

Recoil lug: width—1.16 in.
height—.34 in.
bearing area—.34 sq. in.
clearance from magazine—.87 in.

Guard screws: front—1/4x30
rear—1/4x30

Scope mounting provisions—none

BOLT

Lug shear area—.411 sq. in.

Lug bearing area—.089 sq. in.

Bolt diameter—.694 in.

Lug heights: left (top)—.143 in.
right (bottom)—.123 in.

Bolt face: type—semi-recessed
depth—.047 in.

MAGAZINE

Length—3.40 in.

Depth: front—2.20 in.
rear—2.36 in.

Capacity—6

WEIGHT

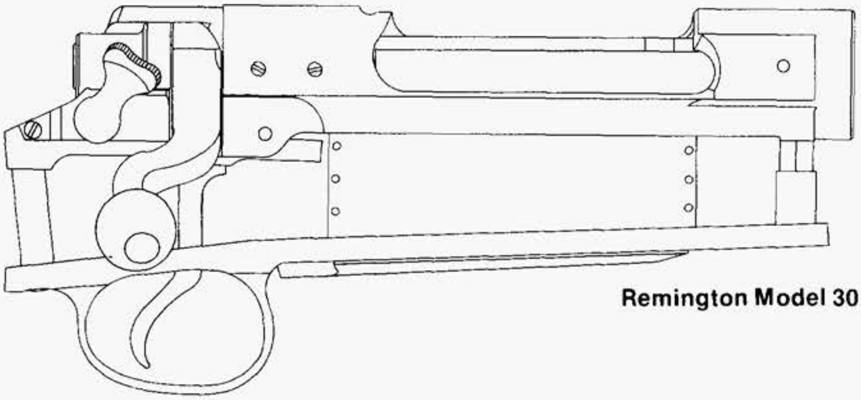
Receiver group—26.3 oz.

Bolt group—14.8 oz.

Magazine/floorplate group—13.1 oz.

Total action weight—54.2 oz.

5
Remington Model 30



Remington Model 30

World War I introduced the bolt action to millions of Americans previously oriented to lever-action rifles. This, combined with large inventories of Enfield parts and machinery left at Ilion from the wartime production, influenced the early introduction of a Remington centerfire turnbolt sporter. The rifle, designated the Model 30, was introduced in 1920.

The Model 30 was more than a derivation of the M1917 Enfield, it was essentially a sporterized military action. It, in fact, never even had its own complete set of engineering drawings. Remington only prepared drawings showing those dimensions differing from the Enfield.

The new rifle was built on the Enfield machinery and mostly from parts left from the wartime inventories. It may seem far-fetched that Remington could produce sporting rifles for twenty years (plus a modest number of military and law-enforcement rifles) on this basis, until some of the numbers are examined. Military contracts during World War I involved huge production quantities, and Remington was putting out several thousand Enfields a day. In the following twenty years, 22,738 Model 30s were sold, thus equaling perhaps a week's wartime inventory. Model 30, and later Model 720, production could have easily continued for many years longer than it did were the availability of Enfield parts the only consideration.

Despite the fact that the Model 30 action, particularly at the beginning, was nothing more than a very modest rework of the Enfield, a precise reconstruction of its design history is difficult. Remington unfortunately never kept good records on this type of thing as some other arms companies have. Nevertheless, a brief outline follows:

Originally introduced in 1920 as the Model 30, it was simply a restyled Enfield, with the bridge milled down and floorplate straightened.

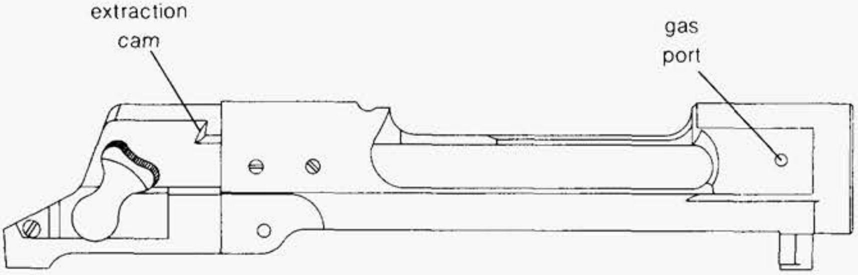
It was converted in 1926 to cock-on-opening by shortening the striker fall. Also, of course, the trigger interlock was deactivated. The rifle at this time became the Model 30 Express.

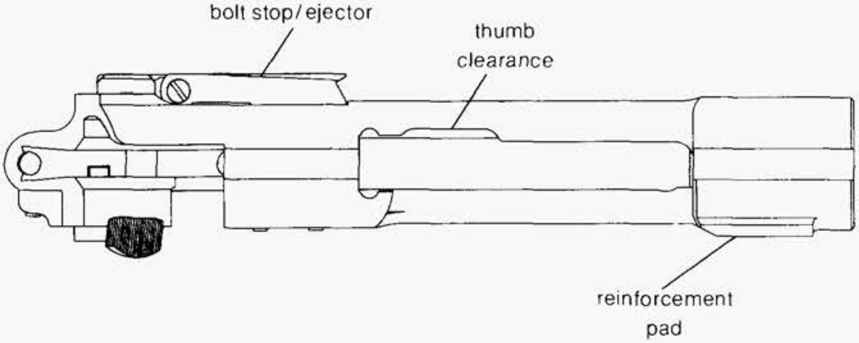
The last major change was in 1930. A Mauser-like guide key system was added, the bolt sleeve was trimmed down, and the firing pin assembly lightened to speed ignition. A new designation was also added, the Model 30S or Special. This designation, however, really more concerned a new higher-grade stock and trim combination also introduced. In fact a Model 30 Express version, with its lesser-grade stock, also continued alongside the new Special until production for both ended in 1940.

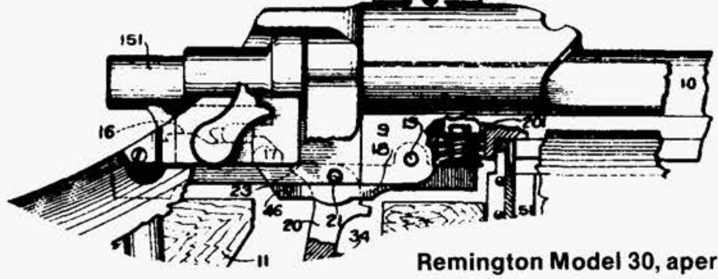
The Model 30 rifle was originally laid out by Crawford Loomis and Charles Barnes. Through the years, Crawford Loomis became responsible for its evolution, as well as, for that matter, much of Remington's firearms line until World War II when Mike Walker took over the rifle program.

Crawford Loomis was a very interesting, if little known gun designer of the period. He was the last of the "old school" of Remington gun designers. Primarily a self-taught engineer, he rose to become Remington's top "in-house" gun designer in the period between the world wars, during which time he obtained a remarkably large collection of patents. Many of these, however, were improvements on the designs of others. At least during the early part of his career (which spanned forty-five years) Remington depended largely on outside designers like Browning and Pedersen for basic inventions. It then fell to Loomis and others to take their prototypes into production. Later, however, Crawford Loomis did develop several original firearms for Remington, including the fine Model 37 rimfire target rifle.

The Model 30 receiver is a reworked Enfield part, with the bridge milled down exactly even with the receiver ring. The tapped hole for the Enfield aperture sight assembly was welded-in and the top of the receiver given a pleasing matted treatment. The original Model 30 incorporated a small commercial version of the Enfield peep sight. A ramp dovetailed into the top of the bridge carried a slide-mounted aperture. By depressing a plunger, it could be moved up or down the ramp with a maximum adjustment range of 550 yards. As with the Enfield, there was no lateral adjustment.


extraction cam
gas port


bolt stop/ejector
thumb clearance
reinforcement pad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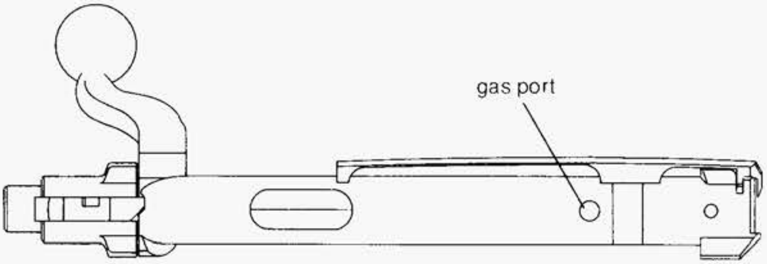
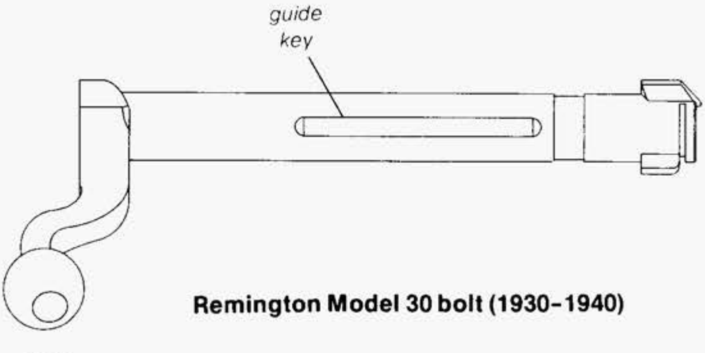
Remington Model 30, aperture sight

All Model 30 bolts were also made from unfinished Enfield parts. In 1926, the deep Enfield holding notch was omitted, thus in effect creating a deeper cocking notch. The 1930 version further modified the bolt by eliminating the milling cuts for the no-longer-used trigger interlock and adding a Mauser-like guide rib and a third gas port. These last two were interrelated. Since surplus bolts were involved, the guide rib could of course not be made integral as in the Mauser M98, and instead it was riveted into a milled slot. The original gas port behind the extractor collar, plus the new port further to the rear, provided the access to set rivets at each end of the guide rib.

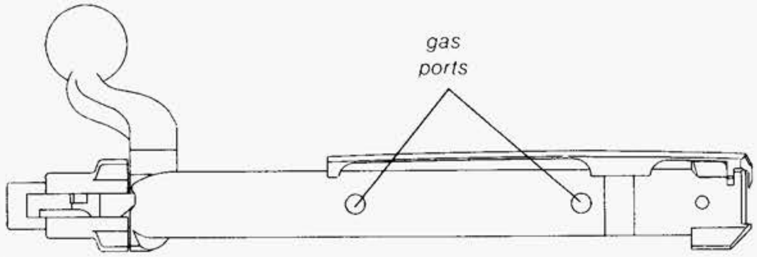
This rib engaged before the right locking lug passed under the ejection port, thus eliminating any binding on the opening cycle. The Model 30 and later the Model 720 had extremely smooth working actions, certainly at least equal in this respect to the more famous Winchester Model 70.



Remington Model 30 bolt (1926-1930)

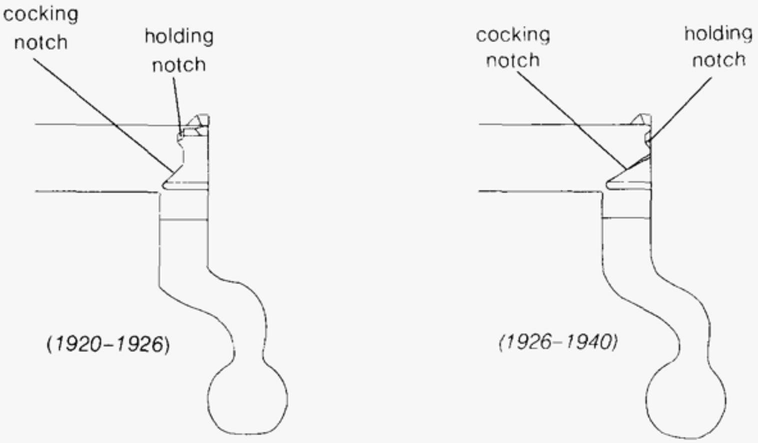


Remington Model 30 bolt (1930-1940)



Reducing the Enfield magazine capacity to five rounds allowed straightening the floorplate frame. Also, the trigger bow was narrowed somewhat, the combination of these changes cutting weight by about two ounces. In calibers like the .30 Remington, however, the assembly actually ended up slightly heavier than the bulky military configuration. Instead of using sheet-metal blocking, solid steel plates were riveted on each end to shorten the magazine.

The Enfield operating cams were not modified. In 1926, however, the cocking system was changed by eliminating the overly deep Enfield holding notch in the bolt rim, thus resulting in .25 in. more mainspring compression on opening. This, combined with a .25 in. shorter striker fall from a modified cocking piece, eliminates the need to compress the mainspring during the initial closing movement and thus converts the action to cock-on-opening.



Remington Model 30, cocking systems

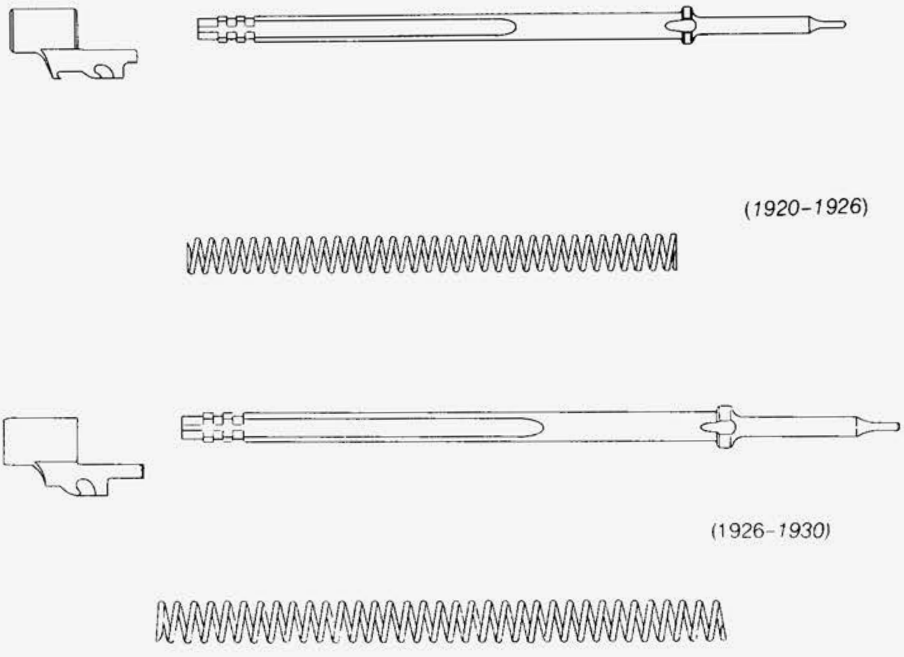
The bolt sleeve remained like the Enfield part, except trimmed in length. In 1926 it was trimmed 1/16 in., and in 1930 an additional 1/8 in.

In the case of the bolt stop, Remington somehow managed to take an awkward system and make it worse. The protruding thumb latch was milled off and replaced by a V-groove. The idea was to use a cartridge rim to swing the bolt stop outward, a further complication to what should be a very simple system. The only advantageous change in this unit was the elimination of the sliver-like Enfield ejector spring in 1926, replacing it with a more sturdy coil spring.

The original Model 30 ignition system was unchanged from the Enfield. In 1926 the cocking piece was redesigned to eliminate the first .25 in. of striker fall. Ignition was improved simply because the shorter striker fall both shortened lock time and reduced the original Enfield impact energy to a more reasonable level.

In 1930, lock time was further reduced, this time by trimming the weight of the firing pin assembly. The original Enfield firing pin was still used, but extensively milled and fluted to reduce its weight from 1.9 oz. to 1.1 oz. Weight was trimmed further by a more streamlined cocking piece. Finally, several coils were added to give a slightly softer, but higher suppression mainspring. Further analysis of these changes in the Model 30 lock systems is included in the Appendix.

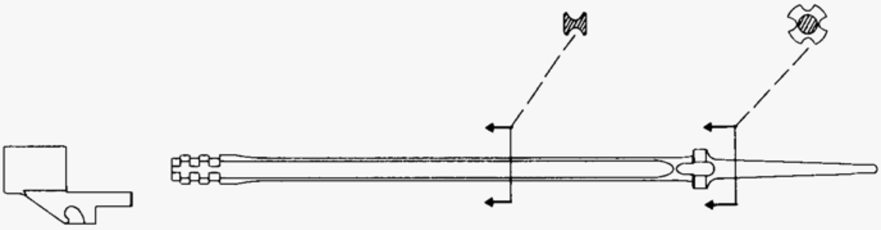
Remington Model 30, firing pin assemblies



(1920–1926)

(1926–1930)

The basic military Enfield direct-pull trigger is used. Both a double-pull and single-pull version—simply modified to a single leverage point—were available. After 1926, with the rifle converted to cock-on-opening, the trigger interlock stud was shortened to deactivate that system.



Remington Model 30, firing pin assembly *(1930–1940)*

SUMMARY

Model 30 production lasted twenty years, yet with less than one-half the total sales of the Winchester Model 54 which came on the market five years later, ended production four years sooner, and was itself not a good selling rifle. A company which had been putting out several thousand Enfields daily was now barely averaging a thousand Model 30s per year.

Among other factors, the fact that the Model 30 was known to be simply a redone military action limited its appeal, particularly since surplus M1917s were practically being given away by the D.C.M. ($7.50), and many gunsmithing firms were specializing in sporterizing these at very reasonable cost. Yet the Enfield action was basically sound, and by the 1930s, the Model 30 had actually evolved into easily the finest sporting turnbolt action in the world, at least until Winchester brought out the Model 70. The changes to the Enfield action were undramatic, but effective, and the Model 30 was an extremely slick and smooth-working action. The following summarizes its strong and weak points:

Strong points:

1. Strong locking and camming.
2. Mauser-type extractor.
3. Integral bolt handle (and backup lug).
4. Direct-acting safety.
5. Positive and controlled ejector.

Weak points:

1. Springfield breech and gas-handling.
2. Direct-pull trigger.
3. Inconvenient floorplate design.
4. Awkward bolt-stop/ejector box.

REMINGTON MODEL 30

Dimensions

OPERATING

Extraction: set-back—.13 in.
leverage—10.5 to 1

Chambering (two-phase):
1st (from cams) cam-forward—.13 in.
leverage—10 to 1
2nd (from angled locking faces) cam-forward—.02 in.
leverage—100 to 1

Bolt rotation—92°

Bolt travel—4.76 in.

	1920–1926	1926–1940
Operating forces:		
bolt lift	2.5 lb.	6.5 lb.
press-forward	18 lb.	—
bolt turndown	3 lb.	3 lb.

	1920–1926	1926–1940
Mainspring compression:		
opening	.117 in.	.365 in.
press-forward	.459 in.	—
closing	.128 in.	.090 in.
trigger pull	.009 in.	.009 in.

IGNITION

		Model 30 (1920–1926)	Model 30 Express (1926–1930)	Model 30 Express and Model 30S (1930–1940)
Firing pin travel:	at impact	.647 in.	.396 in.	.389 in.
	dry-fired	.713 in.	.460 in.	.464 in.
Lock time (ms.)		6.5	5.2	4.1
Impact velocity (ft./sec.)		16.8	13.3	17.0
energy (in.-oz.)		145.5	88.4	94.8
impulse (oz.-sec.)		1.44	1.10	.93

Striker/firing pin diameters—.078 in./.082 in.

RECEIVER

Overall length—8.84 in.

Length of loading/ejection port—3.55 in.

Ring diameter—1.362 in.

Barrel/receiver threads: designation—1 1/8–10 (squared form)
engagement—.6 in. (6 threads)

Recoil lug: width—1.17 in.
height—.36 in.
bearing area—.36 sq. in.
clearance from magazine—.87 in.

Guard screws: front—¼ x 30
rear—¼ x 30

Scope mounting provisions—none

BOLT

Lug shear area—.398 sq. in.

Lug bearing area—.097 sq. in.

Bolt diameter—.696 in.

Lug heights: left (top)—.144 in.
right (bottom)—.122 in.

Bolt face: type—semi-recessed
depth—.037 in.

MAGAZINE

Length: .30-06 Springfield—3.40 in.
.30 Remington—2.89 in.

Depth: front—1.96 in.
rear—2.11 in.

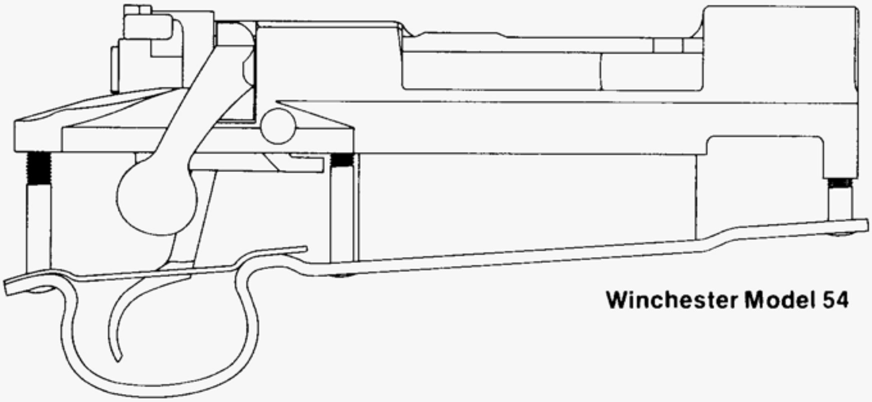
Capacity—5

WEIGHT

	.30-06 Springfield	.30 Remington
Receiver group	21.8 oz.	21.8 oz.
Bolt group	14.8 oz.	14.8 oz.
Magazine/floorplate group	11.6 oz.	14.1 oz.
Total action weight	48.2 oz.	50.7 oz.

6

Winchester Model 54



Winchester Model 54

After World War I, the potential of the bolt action as a sporting arm could no longer be ignored by American arms companies. Several decades of intense technical development had evolved several highly efficient military bolt rifles, which were now thoroughly familiar to millions of U.S. civilians. It was thus natural for the early commercial bolt actions to closely follow existing successful military patterns.

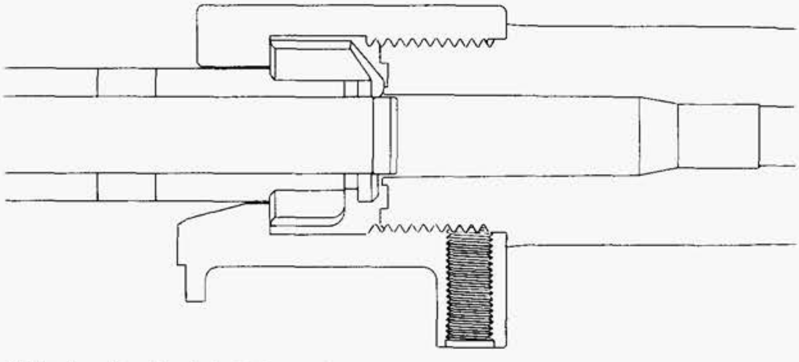
The Remington Model 30 introduced in 1920 was, in fact, nothing more than a sporterized Enfield. The Winchester Model 54, brought out in 1925, was patterned after the Springfield M1903. It shared a great number of Springfield features, but it was an all-new action, not made from wartime inventories as was the Model 30. A number of designers contributed to the development of the Model 54. Principal among these were Thomas Johnson (Winchester's senior gun designer of that era), Frank Burton, Arthur Rowley, Albert Laudensack, and Leroy Crockett.

It took Winchester several years longer than Remington to get into production of a post-war bolt rifle. They were for a long time undecided on a final design, and several prototypes, based on both the Springfield and Enfield patterns, were developed. U.S. Patent 1,355,673 issued to Thomas Johnson on October 12, 1920 shows an early Enfield-based sporter. This approach would have, of course, allowed drawing on a lot of surplus parts stored at the New Haven plant. Obviously, however, the prospect of bringing out something so similar to Remington's Model 30 did not generate great enthusiasm. Perhaps most significant, though, was the influence of big-bore competition on the large arms companies at that time, and there the M1903 was king.

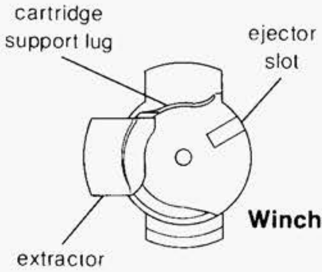
In any event, Winchester ultimately chose a M1903-based pattern. Leroy Crockett, who headed the drafting work, began laying out the details of the Model 54 design in 1922, while in the production department, the long process of modifying the Enfield machine tools and fixtures for the new rifle began. That same year, Winchester finally got into big-bore competition by offering a line of very handsome limited-edition target rifles built on the military Springfield action.

The Model 54 breech was normally coned as in the Springfield. When chambered in .30 W.C.F. (.30-30), however, an interesting variation resulted (shown in the accompanying drawings) which illustrates the inherent strength of the rimmed or flanged cartridge. Unlike the cone, this Model 54 chamber pattern encircles the case head very completely, allowing only the heavy flange to protrude. Smooth functioning from clips and box magazines, and not strength, accounts for the widespread application of rimless or cannelured cartridges.

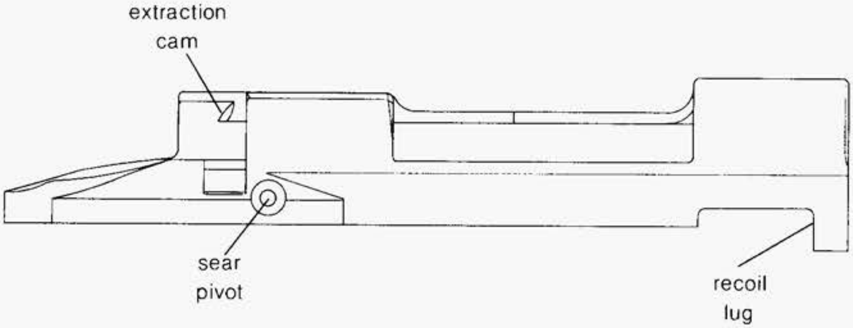
The Model 54 receiver was milled from nickel-steel bar stock. It is massive and geometrical underneath, while streamlined and pleasing on top, with a long low-profile bridge. A deep girder-like midsection shrouds

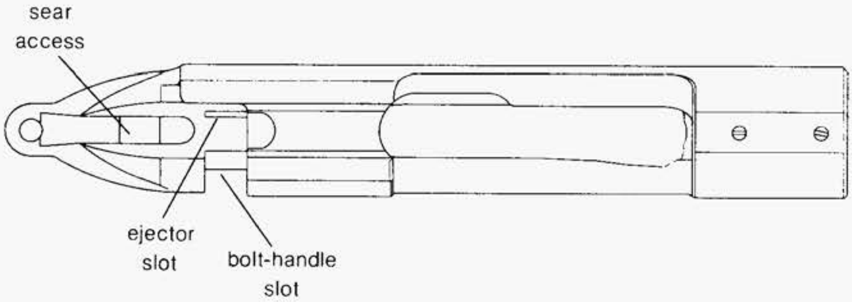


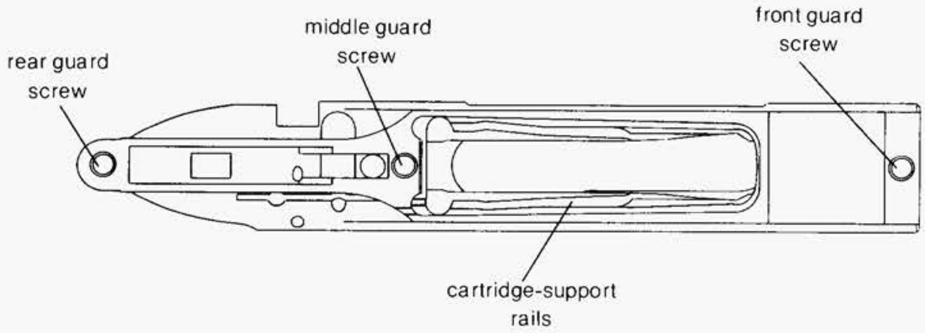
Winchester Model 54 breech, .30 W.C.F. version


cartridge support lug
ejector slot
extractor

Winchester Model 54, bolt face


extraction cam
sear pivot
recoil lug

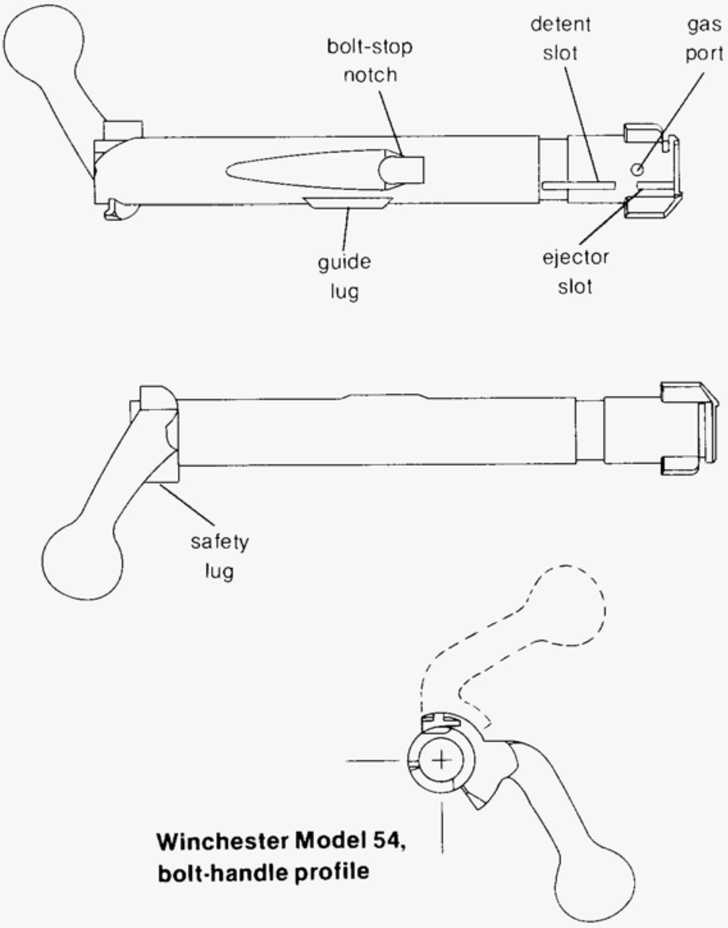

sear access
ejector slot
bolt-handle slot


rear guard screw
middle guard screw
front guard screw
cartridge-support rails

the magazine. The receiver structure itself thus forms and supports much of the magazine, adding rigidity to the action, as well as aiding cartridge feed. This very handsome and efficient basic receiver pattern is retained to this day, in large measure accounting for the success of the later Model 70.

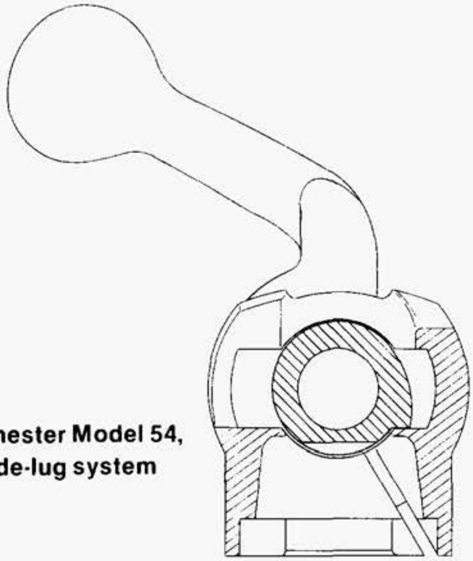
Model 54 rifles, as well as the pre-war Model 70s, were set up for forward-positioned scope mount bases. On the receiver, only the ring was drilled and tapped. The other set of holes were tapped six inches forward on the barrel for a front base.

The bolt is a one-piece forging, with the integral bolt handle bent down similar to the Springfield's. It is neither profiled for scope clearance nor rested in the receiver notch as a safety lug. A separate flange was machined underneath for this latter purpose, giving a strong, if not particularly efficient, safety lug. The primary locking lugs are the same as those of the M1903, except the left lug is unslotted (made possible by relocating the ejector blade), thus giving slightly more shear and bearing strength.



Winchester Model 54, bolt-handle profile

The bolt is fitted with much the same closeness and care as the Springfield bolt and so gives close and even guiding with little cramp-inducing play. While lacking the Springfield safety lug for guiding, it more than compensates with a special guide lug midway on the left side (U.S. Patent 1,631,242 issued June 7, 1927 [F. F. Burton]). This lug is unobtrusive, with its top blended into the bolt diameter and its working surface milled even with the bottom of the left locking lug. Support during bolt movement is thus distributed along the bolt length, rather than concentrated only at the bolt head.



Winchester Model 54, guide-lug system

The extractor is a long externally-mounted Mauser type. It lacks the Mauser angle on the locking tongue and the front face is shaped to snap readily over a chambered cartridge for easy single-loading.

The magazine is a staggered-column box type, with a folded steel cartridge box, brazed together at the rear to form a rigid piece, and a solid machined steel follower. The deep receiver rails which straddle the magazine are contour-milled to position each cartridge accurately as it rises to feeding position.

The most frequently criticized of any Model 54 feature was the heavy steel strap used for the trigger guard and floorplate. Not only did it look cheap, but it lacked the convenience advantages of a detachable floorplate.

The Model 54 handles gas blowback basically like the Springfield, except without any receiver-ring ports or the flared cocking-piece knob to deflect gas escape through the bolt interior.

The bolt has a small gas port at the striker tip juncture. In 1934, a second and larger vent was added just behind the extractor collar. In some calibers, the bolt-stop notch cut through the bolt wall and thus formed another vent.

A rear-driven firing pin is stopped by mainspring stack-up against the front sleeve. Prior to 1932, the firing pin was the same basic two-piece design as in the Springfield, and thus subject to the same weakness. Even with the later one-piece firing pin, however, the sleeve was still a separate part, far more susceptible to failure than the solid flange of the Mauser. Therefore, in 1932, besides going to a one-piece firing pin, the system was further upgraded by adding a safety stop called the *firing pin stop screw* (U.S. Patent 2,099,035 issued Nov. 16, 1937 [A. A. Rowley]). This is a small but sturdy rod threaded into the bolt sleeve and angling across a flat milled into the firing pin shaft. In the unlikely event of mainspring sleeve failure, this screw picks up and wedges against the flat. While it can be distorted or damaged in the process, its protection is extremely positive.

The cam system patterns closely after the Springfield. The recessed and protected extraction cam gives a .16 in. displacement at 8.5 to 1 leverage, while the receiver-ring cams provide a .20 in. movement at 8 to 1 leverage.

The bolt sleeve and safety unit basically follow the Mauser M98, rather than the Springfield pattern. The bolt sleeve looks much like the Mauser's, except without gas-shield flanges. The one Springfield feature adopted was an inward-camming lock system, rather than the sturdier, but more awkward Mauser lock.

The safety is a three-position type of simple one-piece construction, retained on the bolt sleeve and camming against the front of the cocking piece like the Mauser. It is, however, *reversed* (as in the National Match Springfield) with the fire position to the right. This decreases the chance of being struck by the thumbpiece when firing prone, but proved awkward in use for many shooters accustomed to the usual Mauser and Springfield configurations. In 1932, a spring plunger system was added to tension the safety.

The ejector is a flat spring-actuated blade positioned below the left raceway to angle upward into the bolt face. This idea, copied from the Newton rifle, accomplishes two things. First, the cartridge is reached without having to penetrate the left locking lug. Second, and perhaps equally useful, there is enough room under the raceway to avoid the usual external housing on the bridge.

A hump on the ejector blade yieldingly engages a groove under the bolt head to form a detent system (U.S. Patent 1,566,877 issued Dec. 22, 1925 [T. C. Johnson]). It was not intended to detent the bolt open for cartridge loading purposes, like the *bolt stop pin* of the M1903, but simply to prevent it from falling out onto the ground under its own weight if the bolt stop were actuated accidentally with the rifle pointed up. Since the trigger constitutes the bolt stop in the Model 54, battered and muddy bolts were considered a sufficient likelihood to warrant this precaution.

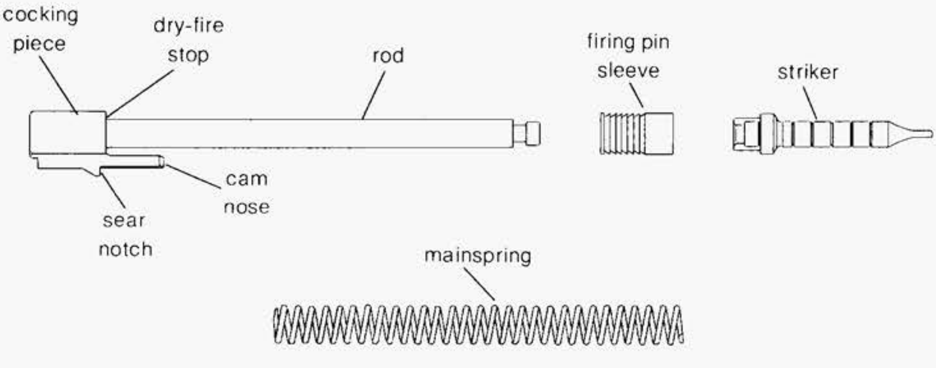
The massive Model 54 sear cooperates with a notch in the underside of the bolt to control the length of its stroke. The bolt illustrated is for the .30 W.C.F. For cartridges like the .30-06 where the notch is closer to the head, it did not penetrate the bolt walls.

The sear never really makes a good bolt stop, even when applied to a rugged direct-pull trigger as in the Model 54. About the only favorable things which can be said are that it is easy and inexpensive to incorporate and the left locking lug is relieved of all strain in this regard. In any event, regardless of the views of most critics, Winchester at the time thought highly of this type bolt stop, enough so for Thomas Johnson to seek protection of the idea (U.S. Patent 1,322,242 issued Nov. 18, 1919).

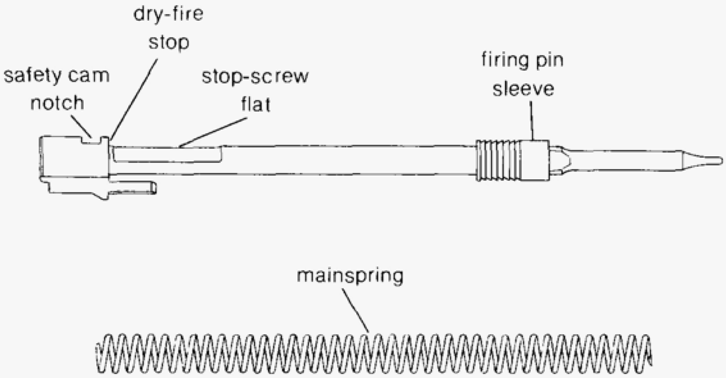
The original Model 54 firing pin assembly basically copied that of the M1903. The sleeve and striker even have the same grooves, although the sleeve has straight rather than concave sides. Lack of the cocking knob and a shorter travel, however, did allow a modest lock-time advantage in the Model 54.

During development of the .22 Hornet, Winchester became highly conscious of the importance of lock time, and in 1932 the Model 54 firing pin assembly was extensively revamped to become the original *Winchester Speed Lock*. In order to distinguish it, Winchester adopted the term *Plain Lock* to describe the pre-1932 assembly.

Winchester thereafter converted Model 54 rifles from Plain Lock to Speed Lock for a cost of $16.80, not really as bad a price as it sounds considering the many new parts involved, including a new bolt. This conversion program, incidentally, accounts for the fact that Model 54s are



Winchester Model 54, plain lock



Winchester Model 54, speed lock

occasionally found with bolts resembling those in the early Model 70. After discontinuing production of the Model 54, the first thing Winchester ran out of was spare bolts (the same thing that later happened when the pre-'64 Model 70 was discontinued). Thus Model 70 bolts were adapted for use in order to continue the factory speed-lock conversions.

At first glance, the Speed Lock firing pin assembly still looks basically like the Springfield's, but it differs in one critical respect. The firing pin is now a single piece, eliminating the weakness and spongy action of the jointed unit.

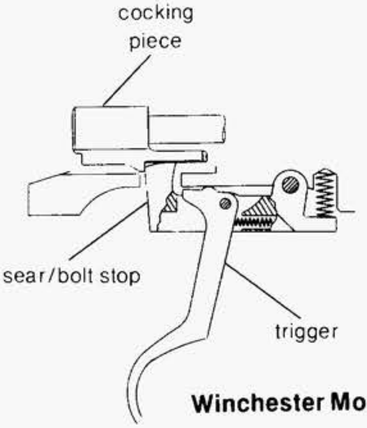
Since the permanent cocking piece still required a front-mounted mainspring, Winchester adopted a removable mainspring sleeve like that in Garand's Super-Speed firing pin (U.S. Patent 1,780,521 issued Nov. 4, 1930). The sleeve is bored out except for a necked-down section at the front broached to a polygonal shape matching the basic cross section of the firing-pin head. To assemble, the sleeve is forced fully back against the mainspring, which positions the polygonal neck over a small groove. The sleeve is then turned 90° and the neck allowed to shift forward onto the adjacent square section, where it is both locked against the firing-pin head and indexed from turning.

There were four different Model 54 mainsprings. Before 1932, there was a standard mainspring essentially equivalent to that of the Springfield, and a shorter version (29 coils) for the .30 W.C.F., which had more solid headspacing. In 1932, two new Speed Lock mainsprings were employed. Standard was a heavy 36-coil version, with a softer 39-coil version for the Hornet. With the shortened striker fall and stronger mainsprings, the Speed Lock ignition cut lock time considerably, helping pioneer the kind of lock system now adopted in most bolt actions.

The Model 54 trigger assembly is a classic direct-pull type, except it is modified to function as a bolt stop. Two design side effects result:

First, the usual position stop between the trigger and sear must be omitted to allow the sear to tension directly up against the bolt and rise into the bolt-stop notch. Since the cocked trigger is thus no longer held rigid by the sear assembly, a lateral spring is added to tension it against the receiver to prevent looseness.

Second, the head of the sear slants forward and thus must be driven down as the firing pin falls. So, as in the later override triggers, there is no clean break with the cocking piece.



Winchester Model 54, trigger assembly

SUMMARY

The Model 54 rifle was only moderately popular, with 50,145 sold over a space of eleven years. Its overall design, at least the pre-1932 version, could be rated no more than equal to the M1903, which was then readily available to civilian shooters at modest cost.

When compared to the Springfield, as it often was, there were several pluses and minuses. On the plus side was the receiver and ejector. The receiver was gracefully styled, yet extremely rigid and with a strong recoil-lug and bedding pattern. The repositioned ejector eliminated interference with the locking-lug pattern. Also, after 1932, the new firing pin was a great improvement over the Springfield.

On the negative side, the bolt stop was poor, resulting in a less than ideal trigger pattern. Likewise, the steel strap trigger guard and floorplate assembly were poorly done.

The following summarizes the strong and weak points of the Model 54 action:

Strong points:

1. Strong, rigid, and streamlined receiver.
2. Integral bolt handle (and backup lug).
3. Mauser-type extractor.
4. Direct acting safety.
5. Positive and controlled ejector.
6. Smooth and positive functioning.

Weak points:

1. Springfield breech and gas handling.
2. Direct-pull trigger.
3. Sear bolt stop.
4. Two-piece firing pin (prior to 1932).
5. Steel-strap floorplate assembly.
6. Lack of low-profile bolt and safety.

WINCHESTER MODEL 54

Dimensions

OPERATING

Extraction: set-back—.16 in.
leverage—8.5 to 1

Chambering: cam-forward—.20 in.
leverage—8 to 1

Bolt rotation—94°

Bolt travel: .22 Hornet—2.92 in.
.30 W.C.F.—3.86 in.
.30-06 Springfield—4.56 in.

Operating forces: bolt lift—4.5 lb.
bolt turndown—4 lb.

Force to close bolt when single loading—9 lb.

		Standard version (1925–1932)	S/L version (1932–1936)
Mainspring compression:	opening	.417 in.	.245 in.
	closing	.078 in.	.008 in.
	trigger pull	.008 in.	.002 in.

IGNITION

	Standard version (1925–1932)	.30 W.C.F. (1928–1931)	S/L version (1932–1936)	Hornet S/L (1933–1936)
Firing pin travel:				
at impact	.411 in.	.411 in.	.205 in.	.205 in.
dry-fired	.503 in.	.503 in.	.255 in.	.255 in.
Lock time (ms.)	5.2	5.7	3.1	3.4
Impact velocity (ft./sec.)	14.2	12.8	12.3	11.3
energy (in.-oz.)	102.5	83.0	69.7	58.5
impulse (oz.-sec.)	1.20	1.08	.95	.87

Striker/firing pin diameters—.073 in./.081 in.

RECEIVER

Overall length—8.75 in.

Length of loading/ejection port—3.12 in.

Ring diameter—1.353 in.

Barrel/receiver threads: designation—1-16
engagement—.60 in. (9½ threads)

Recoil lug: width—1.18 in.
height—.43 in.
thickness—.360 in.
bearing area—.38 sq. in.
clearance from magazine—1.31 in.

Guard screws: front—¼x32
middle—¼x32
rear—¼x32

Scope mounting—6x48 screws

BOLT

Lug shear area—.397 sq. in.

Lug bearing area—.079 sq. in.

Bolt diameter—.692 in.

Lug heights: left (top)—.143 in.
right (bottom)—.121 in.

Bolt face: type—semi-recessed
depth—.045 in.

MAGAZINE

Length—3.40 in. (.30-06 Springfield)

Depth: front—1.88 in.
rear—2.09 in.

Capacity: .22 Hornet—5
.30 W.C.F.—5
.30-06 Springfield—5

WEIGHT

Receiver group—21.5 oz.

Bolt group—15.0 oz.

Magazine/floorplate group—9.0 oz.

Total action weight—45.5 oz.

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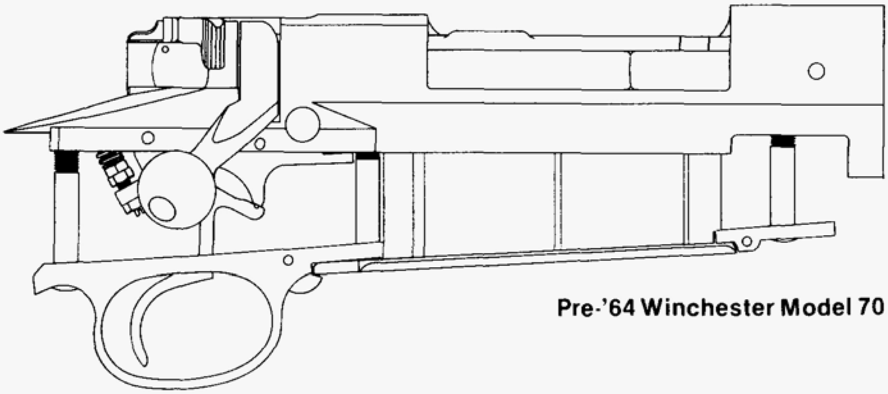
Pre-'64 Winchester Model 70



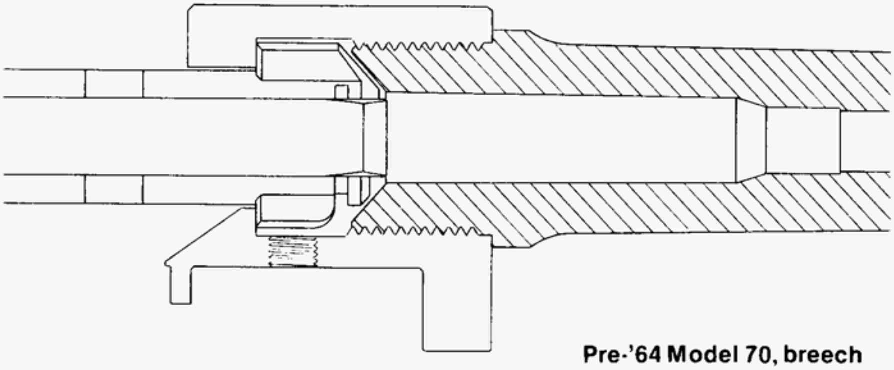
Pre-'64 Winchester Model 70

By the 1930s, after several years of analyzing and working out the strengths and weaknesses of the Model 54, Winchester had acquired a good concept of what features did, and what features did not, contribute to a modern top-quality bolt-action sporting rifle. The design of the Model 54 action was not simply scrapped and replaced with something new and untried, as is often the case. Instead, the Model 70 represents a careful, and uniquely successful, refinement of the Model 54, retaining all the strong features and redoing only the weak areas. Because of this evolutionary process, it is difficult to pin down a specific group of designers as responsible for the Model 70; however, most credit can be given to Leroy Crockett and Albert Laudensack, working under the direction of Edwin Pugsley.

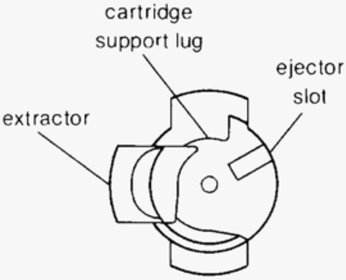
Design of the Model 70 was finished by 1934, and authorization for its manufacture was granted on Dec. 29 of that year. Production was delayed, however, and the first shipment of rifles was not until Aug. 14, 1936.

A wide variety of Model 70 chamberings through the years has produced numerous variations in the bolt and magazine areas. This, combined with minor functional improvements during its twenty-eight year life, makes an interesting and quite extensive study in itself. This chapter, however, will concentrate primarily on basic design and functioning, rather than a cataloging of variations. A post-war Model 70 chambered for .30-06 was used for most of the measurements and illustrations. Features carried over unchanged from the Model 54, like the extractor, ejector, cams, and locking lugs, are not repeated here.

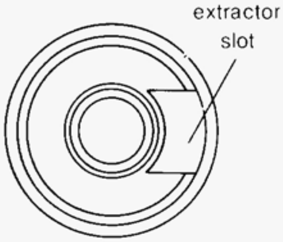
The Model 70 also retained the Springfield breech. The coned barrel, combined with the massive non-rotary extractor, receiver-mounted ejector, and partial bolt-face rim added up to form a system tailored to feed, extract, and eject cartridges with the utmost speed and certainty. Purely from that standpoint, there has never been a better system. And to try and prove this cone breech unsound from a cartridge-head support standpoint is pointless. It has proven adequate through decades of hard use.



Pre-'64 Model 70, breech

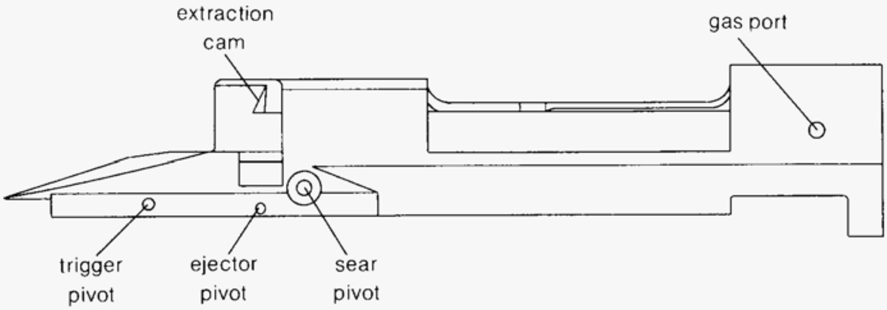


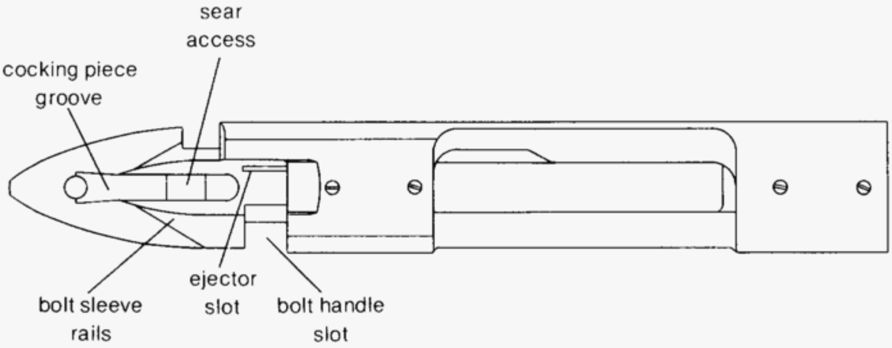
Pre-'64 Model 70, bolt face

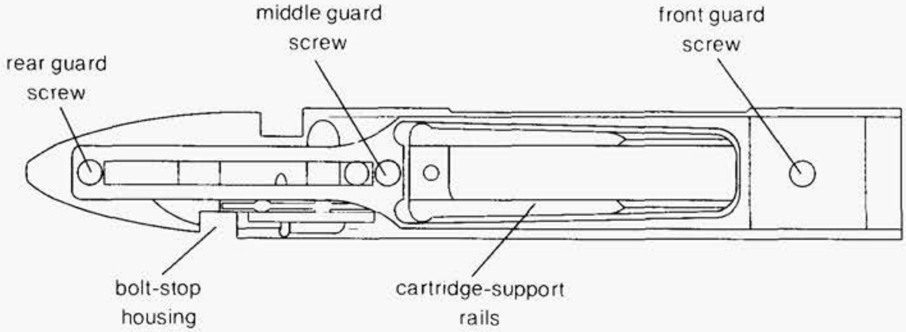


But design of U.S. sporting arms in recent years has put greater emphasis on support of the cartridge head. Remington strengthened this aspect shortly after World War II with the 721/722 series. The Model 70 change in 1964 both seats the cartridge deeper into the barrel and better shrouds the protruding head than did this classic version. Interestingly enough, some of the now long obsolete turnbolt actions, developed when the metallic cartridge was in its early and thus more uncertain stages, gave perhaps the most complete cartridge-head support of all.

The receiver was carried over almost unchanged in form from the Model 54, a wise choice as it represents almost a work of art from solid steel. The entire action, in fact, strikes a remarkable balance of grace and ruggedness which has few, if any, peers. About the only problem with the receiver was chipping of the stock where the cloverleaf-shaped rear tang was inletted. In 1947, the tang was restyled to give an overhanging outer edge which lies entirely on top of the stock, thus eliminating the need for any close inletting in this area.


extraction cam
gas port
trigger pivot
ejector pivot
sear pivot

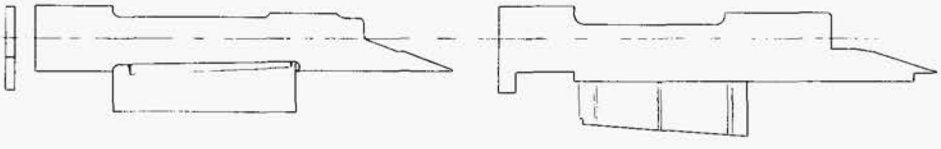

sear access
cocking piece groove
bolt sleeve rails
ejector slot
bolt handle slot



Contrary to what many assume, the receivers were not forged, but were machined from 9 7/16 in. lengths of 1 1/2 x 1 7/8 in. chrome-moly barstock. A lot of steel was machined away in transforming this massive slab to final size and shape in a process involving about 75 operations. The raw slab weighed 120 oz., the final-machined Model 70 receiver 19.3 oz. Thus, almost 101 oz., or 84%, was machined away. As a comparison, the Remington Model 700 starts as a 64 oz. length of round barstock, ending up as a 15 oz. finished piece. An even more extreme comparison is the Ruger Model 77 receiver. It is cast into a 20 oz. billet, and weighs 16.3 oz. after final machining.

The principal change made to this long and extremely sturdy receiver was moving the front guard screw rearward from the recoil lug to the front bedding flat for the Model 70. The new centered location not only evenly distributes tension, but the clamping action now helps reinforce the recoil area of the stock. This, combined with a much larger, better positioned recoil lug than used in the classic military actions, and an exceptionally stiff receiver midsection, permits very stable bedding, a key to the Model 70's long history of success in competitive shooting.

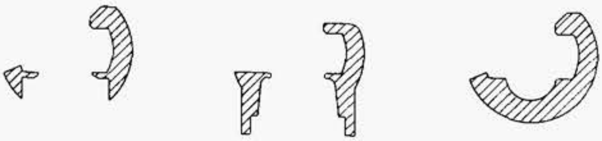
One occasionally reads how siderail receivers lack the rigidity of cylindrical types, this conclusion usually supported by comparing the Remington Model 700 and Mauser M98. Yet, the Model 70 proves that the siderail type can also be made very stiff. As the accompanying drawings show, its deep girder-like midsection makes it one of the most rigid bolt-action receivers ever designed.



Remington Model 700
(.30-06)

Pre-'64 Winchester Model 70
(.30-06)

Magazine shroud

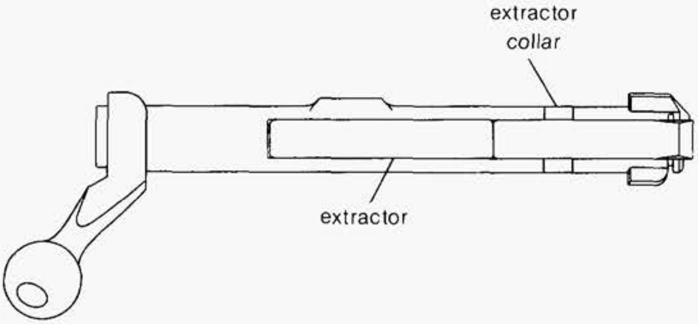


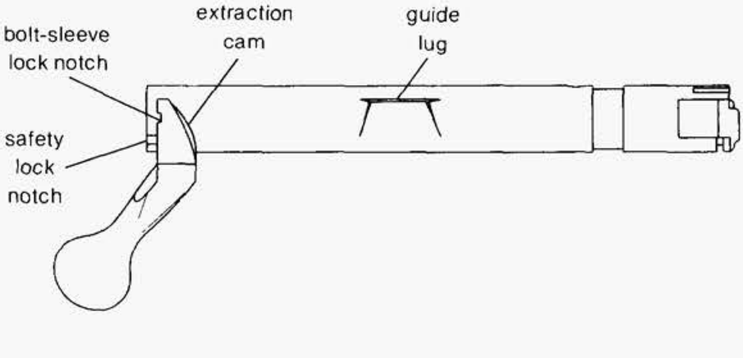
Remington Model 700 *Pre-'64 Model 70* *Remington 40-XB*

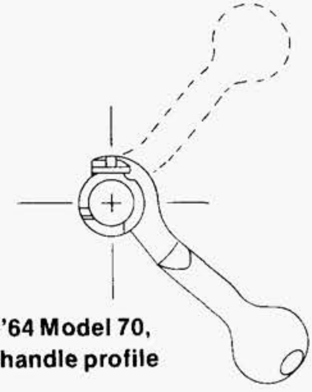
Receiver midsections

While there was only one basic size, there were three basic Model 70 receivers. A standard version for all cartridges except the belted-head magnums, a second for the short magnums with a widened magazine well, and a third for the H&H magnums with the magazine well lengthened by cutting forward into the lower locking seat.

The Model 70 bolt is a one-piece chrome-moly steel forging. In order to allow scope clearance, the bolt handle comes off at a 45° angle, rather than straight out as in the Model 54. It turned out to be not quite as low-profiled as some scopes required, however, and in post-war versions a slight additional clearance is milled into the top surface of the bolt-handle shank. The bottom of this shank fits a notch in the receiver as a backup lug. Beyond this, the handle sweeps gracefully rearward, ending in a tear-shaped knob, hollowed-out on bolts made after 1953. Like the rest of the action, the bolt handle is shaped and proportioned into a much-copied blend of grace and utility.







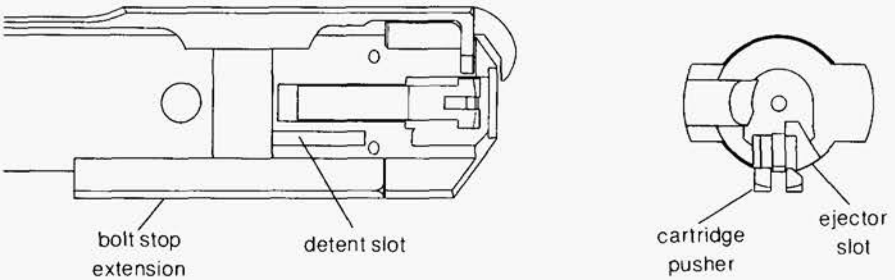
Pre-'64 Model 70, bolt-handle profile

While it may seem that way, the low-profile bolt was far from being a new idea developed in the mid-1930s. It was simply a matter that without telescopic sight mounting, it was not considered to be an ideal configuration. The M1917 Enfield, of course, had a perfect low-profile bolt designed way back around 1910. The even earlier Krag bolt was also low profile. Perhaps most interesting, Winchester designer Thomas Johnson was issued U.S. Patent 1,225,640 on May 8, 1917, detailing a very handsome swept-back and low-profile bolt styled almost exactly like that used much later on the Remington Model 720, and also very similar to the Winchester Model 70 bolt. Yet telescopic sights did not really become important until many years later, and so when he designed the Model 54, the feature was omitted.

While Model 70 bolts, like the receivers, were all the same basic size, detailed differences resulted in three different bolts. The standard version with a .483 in. bolt face, a magnum version with a .541 in. bolt face, and the Hornet bolt with a .356 in. bolt face plus several special bolt head features.

Winchester got a lot of mileage from one basic action, since through the years cartridges spanned all the way from the little .22 Hornet to the long H&H magnums. Actions for cartridges shorter than .30-06, around which the Model 70 was designed, had the bolt short-stroked by means of a bar-like part called the *bolt stop extension.* It fitted opposite the extractor as part of a special collar, lining up behind the left locking lug when the bolt was opened to contact the bolt stop early and thus eliminate unnecessary travel. It was made in three lengths, the longest for the Hornet bolt.

A very special bolt head pattern was used for the Hornet cartridge, which obviously needed special handling to prevent getting lost in the big Model 70 action. Besides a smaller bolt face and extractor claw, it has a unique cartridge pick up system. A small spring-loaded *cartridge pusher* pivots under the bolt face to scoop into a small inner magazine on the forward bolt stroke. It is beveled to cam up into the bolt-face proper once the cartridge is started on its way, and thus not interfere with the locking phase. With this lever added, the bolt head becomes a crowded and elaborate affair, and Hornet actions were the most expensive for Winchester to manufacture, although the rifles sold for no more than those in other calibers.



.22 Hornet bolt head

This special Hornet pattern was a patented feature (U.S. Patent 1,898,670 issued Feb. 21, 1933 [A. F. Laudensack]) carried over from the Model 54. In this Winchester patent, Mr. Laudensack discusses the cone breech, particularly its adaptation to the Hornet cartridge. Neither the Model 54 nor Model 70 barrels was counterbored for the Hornet rim, because of concern over feeding jams. It was allowed to simply headspace on the cone, certainly a practical, if not necessarily optimum, solution.

The magazine is a double-column type with a folded and brazed sheet metal cartridge box as in the Model 54. The standard size cartridge box was blocked with sheet-metal spacers for cartridges shorter than .30-06. For the H&H cartridges, the receiver was milled out longer for an oversize box and follower assembly, removing some of the lower locking seat in the process. For the short magnums, the magazine is only wider.

The Hornet version was again the most elaborate. A miniature double-column magazine assembly fits within the standard cartridge box. It slants forward to separate the Hornet rims, with a long guide sprout to blend with the regular feed ramp. The ejector fits to the blocking immediately behind this inner box, rather than its usual location under the bridge.

A trigger bow and floorplate unit of milled steel replaced the metal strap parts of the Model 54. This change was probably of more significance to the average shooter and gun critic than any of the others which formed the Model 70. In 1952, a featherweight version was introduced where these steel parts were replaced with aluminum alloy.

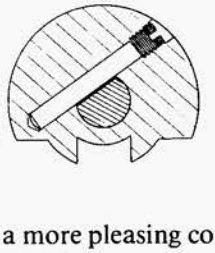
Rather than a rigid one-piece arrangement as in the Mauser and Springfield, the trigger bow/floorplate in the Model 70 is a rather peculiar two-piece arrangement. The floorplate hinges to a small plate under the front guard screw, while a separate trigger bow is flanged for the middle and rear guard screws. The catch, copied from the Newton rifle, is simply a small angled plunger in the front web of the trigger bow.

It is difficult to find any functional advantage to the two-piece unit. One obvious drawback is that extra care is sometimes required in assembling the action to the stock without jamming either the floorplate release or bolt-stop assemblies. The plunger catch also is less than ideal. There is little purchase available on its beveled end, making finger-tip actuation against its strong spring quite difficult.

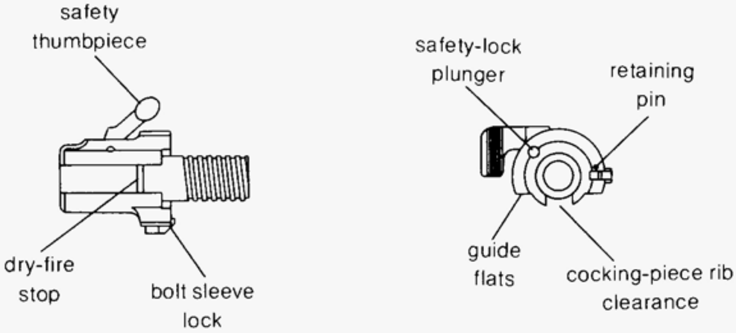
The Model 70 receiver ring adds a small gas port on the right side next to the extractor. Gas entering the firing pin hole is released by two ports in the bolt head facing the left raceway like those in late-version Model 54 rifles. On those Model 70s with short-stroked bolts, however, the ports are covered by the bolt stop extension. This is probably just as well, since the left raceway is not blocked off at the rear. This idea of concentrating pressure into a raceway, which is little more than a straight route back toward the shooter's face, goes back to the Springfield. In the Model 70, there is not even the slight gas-deflecting protection of the Springfield cocking knob.

A firing pin driven to the rear by gas release is stopped about 1/3 in. past full-cock when the mainspring goes solid. It may be noted that this is significantly less than the snap-back in actions with detachable cocking pieces. This characteristic, in itself desirable, stems from the fact that a forward-mounted mainspring requires less dead-space for assembly. Backing up mainspring stack-up in the Model 70 is the *firing pin stop screw* used in the late-version Model 54s.

Pre-'64 Model 70, firing pin stop screw



The bolt sleeve was given a more pleasing contour in the Model 70. It still retains the same threads and indexing system as in the Model 54. The main functional change was the position and design of the safety. While still a three-position type, it now pivots on an offset vertical axis, rather than parallel to the firing pin axis.



Pre-'64 Model 70, bolt sleeve

The thumbpiece of the Model 70 safety originally moved across the top of the bolt sleeve. This was soon modified to confine the swing entirely to the right side for easier operation under a scope. Later, a final modification completed this conversion by adding a turned-down leg to allow the thumbpiece to be more readily grasped from the side. This safety is convenient, positive, and silent. Operation is outlined below:

With the thumbpiece turned to the right, the safety spindle deactivates the firing pin by camming the cocking piece rearward. The bolt itself, however, is not locked. Thus this intermediate position, like those in the Mauser, Springfield, and Model 54 safeties, allows working cartridges through the rifle in relative safety, as well as easy field stripping of the bolt assembly.

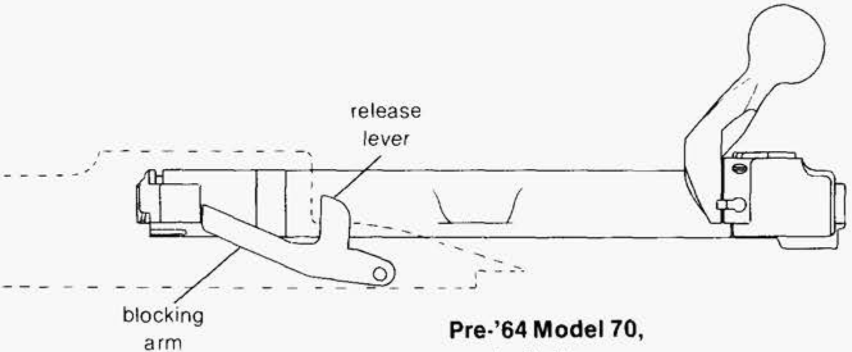
Swung back to *safe*, the firing pin remains locked, while a lock-down plunger is cammed forward to also lock the bolt.

Swung forward to *fire*, the spindle releases the firing pin and eases it back into contact with the trigger assembly. Simultaneously, a recess in the safety-lock head allows the lock-down plunger to shift rearward and free the bolt.

A separate bolt-stop system was one of the Model 70's big improvements over the Model 54. Not only was the sear relieved of this function, but in so doing Winchester also avoided a return to the clumsy externally mounted units of the military bolt actions.

The Model 70 bolt stop is a heavy blade which pivots on the trigger pin and is housed within the receiver proper, below the left lug raceway. It projects upward to block the locking lug (or bolt stop extension on short-stroked actions) and is positioned by a small spring-loaded plunger in the bridge. A thumb projection allows rotating the tip of this blade down flush for bolt removal. Bolt insertion automatically overrides the blade.

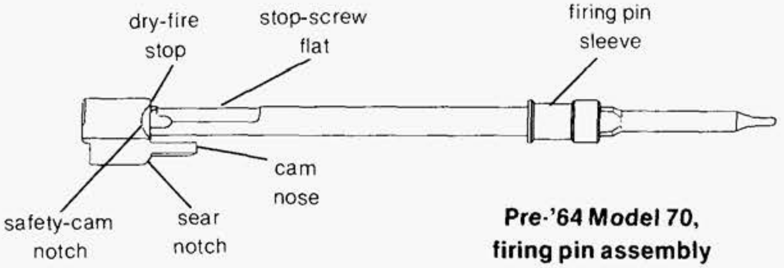
Winchester adopted a slight modification of the Model 54 *Speed Lock* ignition for the Model 70. The only noteworthy functional change was a slight increase in the length of striker fall. In 1932 it had been reduced in the Model 54 from 1/2 to 1/4 in. The Model 70 compromised at a little greater than 5/16 in., giving a lock time only slightly slower than in the late Model



Pre-'64 Model 70, bolt stop

54 rifles, while at the same time a substantially better impact energy. As in the Model 54, Winchester continued with a softer and less powerful mainspring in the Hornet rifles.

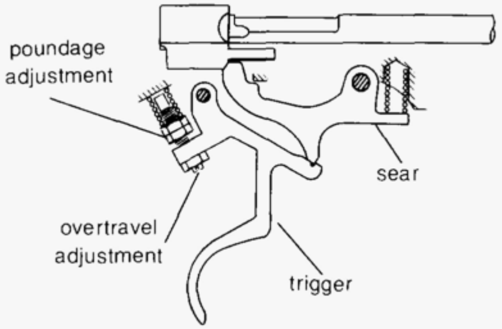
Mechanically, the same Model 54 *Speed Lock* features were continued, including the one-piece firing pin with Garand-type mainspring sleeve attachment, and the excellent *firing pin stop screw.* Early Model 70s even retained the grooves on the mainspring sleeve.



Pre-'64 Model 70, firing pin assembly

The Model 70 introduced a new trigger which did not have to double as a bolt stop. It was important to correct that fault of the Model 54, but purely from the standpoint of trigger design, that improvement was incidental. What placed the Model 70 trigger in a class apart from the trigger in the Model 54 or, for that matter, those in any of the other available centerfire turnbolt actions of the time, was its breakaway or override action. Yet, for some reason this aspect of the Model 70 trigger never really got too much attention from the gun writers of the era, or even the Winchester marketing department for that matter.

The basic principle of the override trigger actually goes back a long way. It was used in the swinging-block action of Friedrich von Martini (U.S. Patent 90,614 issued May 25, 1869). A few years later, William Wetmore of



Pre-'64 Model 70, trigger assembly

Winchester adopted it to the Hotchkiss bolt action (U.S. Patent 223,662 issued Jan. 20, 1880). It did not really catch on in bolt actions until much later, however, when Winchester and Remington began to get serious about rimfire target rifles. Winchester rediscovered the virtues of the override trigger in the late 1920's when Frank Burton developed a version for the Model 52 (U.S. Patent 1,741,281 issued Dec. 31, 1929). Over the next few years, several more patents were issued to Winchester and Remington engineers as they continued to refine the firing units of the Model 52 and Model 37; however, the basic principle shown by Martini remained unchanged.

Today, the override trigger is virtually standard on the centerfire bolt action. While it has a single or continuous takeup, in contrast to the double or interrupted takeup of the classic military direct-pull trigger, the essential difference involves the actual mechanics of sear release. In the override trigger the sear is separate and is spring-urged upward to block the cocking piece. The firing pin assembly can easily overpower the sear, which thus must depend on support from the trigger. Displacement of the trigger piece allows the striker to instantly snap it down. This *breakaway* or *override* action distinguishes it from the direct-pull type, where the sear is not overridden, but is cammed down by the trigger.

The override trigger can function with minimum trigger pull, much less than practical in a direct-pull type. Because of the inherent play in the cocking-piece/bolt-sleeve assembly, either type requires a substantial engagement between the sear and the cocking piece to hold safely when the bolt is closed hard. In a direct-pull trigger this engagement controls trigger movement. In an override type it represents only the automatic secondary release. Instead, engagement between the sear and the trigger piece controls trigger movement. This can safely be made much smaller, thus affording a finer action, because the sear can be located in a much more certain and precise manner relative to the trigger piece than to the cocking piece.

SUMMARY

The pre-'64 Model 70 was for many years the premier American bolt-action rifle. Winchester stuck mostly to proven design concepts, and its strong points were aesthetic appeal, careful detail engineering, and honest quality. It was billed in Winchester advertisements as "The Rifleman's Rifle," a title which it had indeed earned.

Production cost was the ultimate demise of the classic Model 70. The design was not well suited to the application of modern machining techniques, making it difficult to continue manufacture in this country at a competitive price, while also maintaining a high quality of finish. The following summarizes the action's strong and weak points:

Strong points:

1. Strong and rigid receiver.
2. Integral bolt handle (and backup lug).
3. Mauser-type extractor.
4. Adjustable override trigger.
5. Direct-acting safety.
6. Smooth and positive functioning.
7. Positive and controlled ejector.
8. Exceptionally clean and attractive lines.

Weak points:

1. Springfield breech and gas handling.
2. Inconvenient floorplate release.
3. Two-piece trigger guard/floorplate assembly.

PRE-'64 WINCHESTER MODEL 70

Dimensions

OPERATING

Extraction: set-back—.16 in.
leverage—10.5 to 1

Chambering: cam-forward—.18 in.
leverage—10 to 1

Bolt rotation—87°

Bolt travel: .22 Hornet—2.98 in.
.250 Savage—3.93 in.
.308 Winchester—4.06 in.
.30-06 Springfield—4.59 in.
.375 H&H—4.59 in.

Operating forces: bolt lift—5 lb.
bolt turndown—6 lb.

Force to close bolt when single-loading—11.5 lb.

Cock-on-opening; .319 in.
mainspring compression
proportioned as follows:
opening—.215 in.
closing—.104 in.

IGNITION

Firing pin travel: at impact—.261 in.
dry-fired—.319 in.

	Standard version	.22 Hornet
Lock time (ms.)	3.5	3.8
Impact velocity (ft./sec.)	13.6	12.6
energy (in.-oz.)	86.1	74.8
impulse (oz.-sec.)	1.05	.99

Striker/firing pin hole diameters—.076 in./.078 in.

RECEIVER

Overall length—9.14 in. (pre-war cloverleaf style—8.77 in.)

Length of loading/ejection port—3.14 in.

Ring diameter—1.357 in.

Barrel/receiver threads: designation—1-16
engagement—.60 in. (9½ threads)

Recoil lug: width—1.17 in.
height—.43 in.
thickness—.360 in.
bearing area—.50 sq. in.
clearance from magazine—1.31 in.

Guard screws: front—¼x32
middle—¼x32
rear—¼x32

Scope mounting—6x48 screws (ring only on pre-war versions)

BOLT

Lug shear area—.398 sq. in.

Lug bearing area—.071 sq. in.

Bolt diameter—.693 in.

Lug heights: left (top)—.140 in.
right (bottom)—.115 in.

Bolt face: type—semi-recessed
depth—.045 in.

MAGAZINE

Length: .30-06 Springfield—3.40 in.
.375 H&H—3.63 in.

Depth: front—1.90 in.
rear—2.10 in.

Capacity: .22 Hornet (.350 in. rim)—5
.30-06 Springfield (.473 in. head)—5
.375 H&H (.532 in. head)—4
.300 Winchester Magnum (.532 in. head)—3

WEIGHT

	Standard	Featherweight
Receiver group	21.8 oz.	21.8 oz.
Bolt group	14.5 oz.	14.5 oz.
Magazine/floorplate group	9.2 oz.	6.3 oz.
Total action weight	45.5 oz.	42.6 oz.

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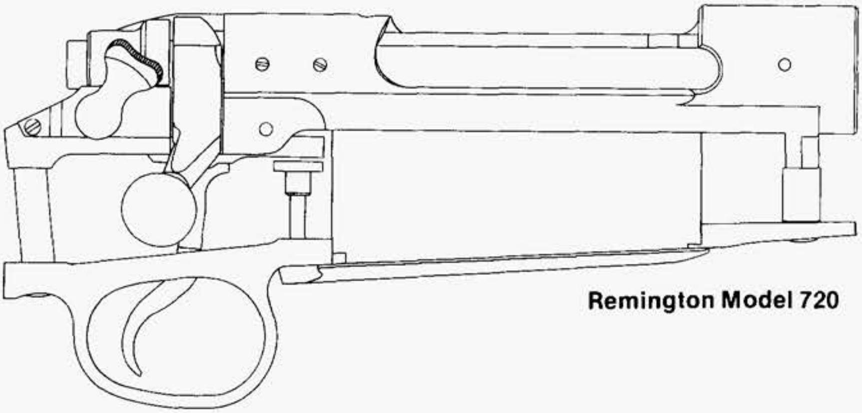
Remington Model 720



Remington Model 720

The Model 720 was one of the shortest-lived U.S. sporting arms, due as much as anything to unfortunate timing. Production started in 1941 and was underway only about a year when Remington converted its Ilion facilities over to build the Springfield rifle under Government contracts.

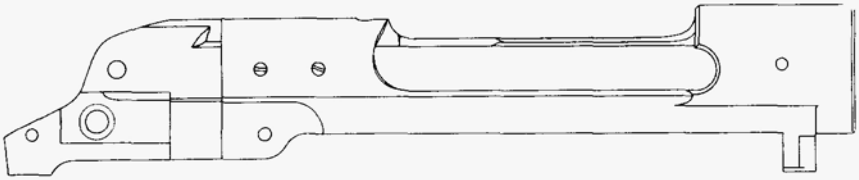
Even though manufacture was stopped, sales continued through 1944, with a total of 2,427 rifles shipped. (Model 720 serial numbers run in the 40,000s and thus require some explanation. The last Model 30 was serial no. 30,540. In order to avoid confusion between the two series, Remington started the 720 serial numbers at 40,000 rather than zero.)

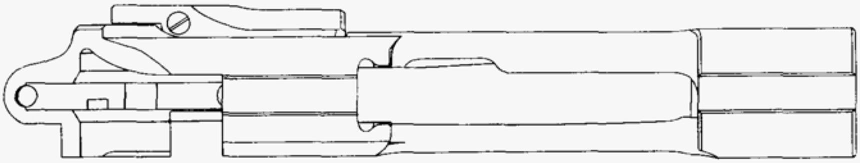
Despite their use of surplus parts, both the Model 30 and 720 were consistent money losers. Thus when Springfield contracts were completed in 1944, the 720 became the first casualty of Remington's reconversion and modernization program and was ultimately replaced in 1948 by the completely new 721/722 series.

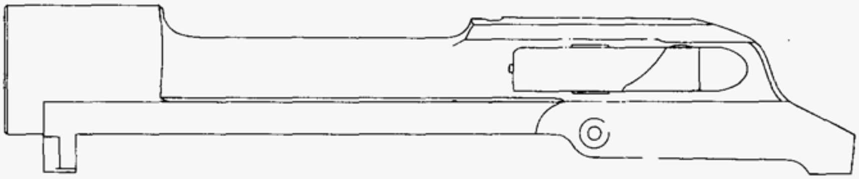
Like the Model 30, the Model 720 was designed primarily by Crawford Loomis, but also with help from his brother Oliver and from Aubrey Lowe. Despite its economic shortcomings, from a pure design viewpoint the Model 720 had considerable merit. There were only a modest number of changes from the last version of the Model 30, yet these did correct many of its design faults and the 720 evolved into the near-ultimate potential of the basic Enfield pattern. It retained the inherent Enfield mechanical strengths while smoothing out some of the rough spots, and was also the best looking Enfield. Had circumstances allowed it to become more abundant and better known, it could certainly have become at least a serious rival on equal terms to the Winchester Model 70.

The many features unchanged from the Model 30 are not repeated here. These include the breech, locking lugs, bolt guiding, extractor, gas ports, cams, bolt sleeve, and safety. As with the Model 30, Remington continued to draw on its stockpile of Enfield parts for the major portions of the action, including the bolt and receiver.

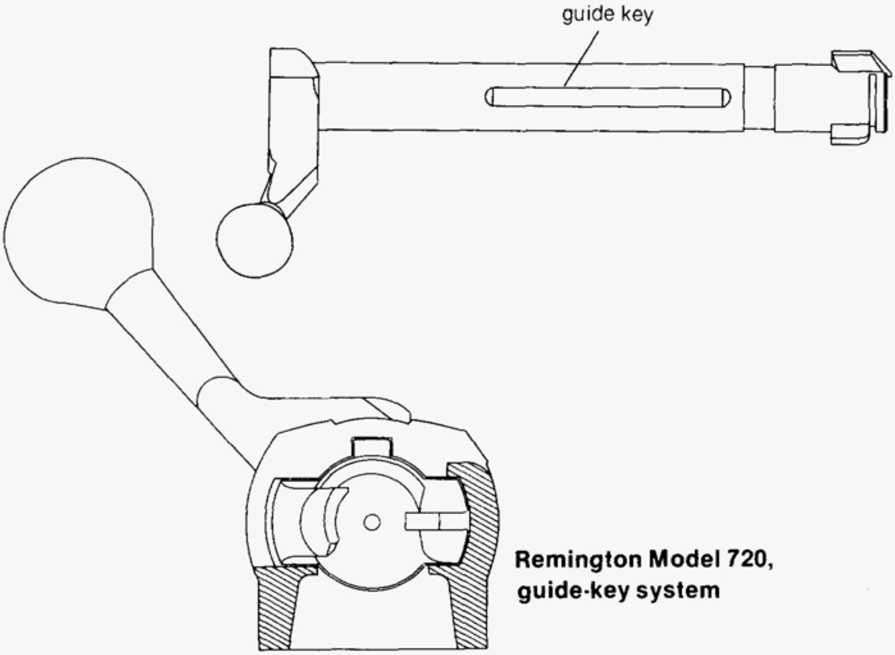
The Enfield receiver was considerably streamlined in the transition from the Model 30 to 720. To get further away from the military look, the reinforcing pad was machined off the receiver ring to give a round cross-section. The bridge, which in the Model 30 was milled exactly even with the ring, was flattened about 1/8 in. to give a low-profile like the Model 70 Winchester. Finally, the rear of the bridge was given a more pleasing profile and the left side was remachined for a new bolt stop/ejector assembly.



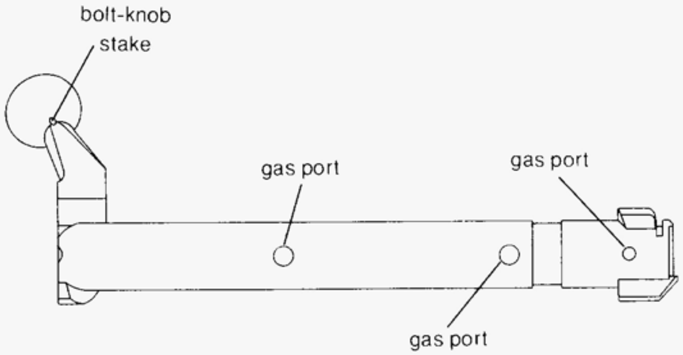


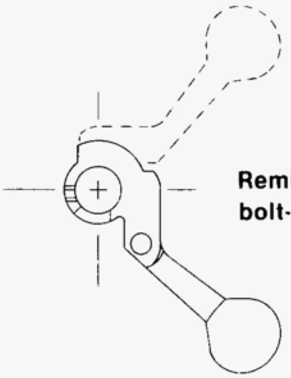


The bolt was modified in two ways from the Model 30. The cocking cam is much shallower to accommodate a shorter striker fall. The most striking change is the bolt handle. The dog-leg shape, which always hurt the looks of Enfield-based rifles, was finally changed by simply cutting off the lower portion of the dog leg. The remaining shank was straightened and threaded for attachment of a pear-shaped knob which was then staked in place. Thus the original low-profile and integral shank was retained and the improvement accomplished quite inexpensively. This straightening of the shank also moved the bolt knob slightly forward to a better position relative to the trigger. One functional result of the new shape was a reduction of about 15% in the effective length of the bolt handle. Since the camming systems remained otherwise unaltered, cam leverages decreased a corresponding amount.



Remington Model 720, guide-key system





Remington Model 720, bolt-handle profile

The 720 cartridge box remained a surplus part, but was ground away on the sides to reduce weight. Underneath, the trigger guard/floorplate assembly comprises all new parts and was a curiously unsuccessful attempt to improve the previous pattern. The Model 30's one-piece steel trigger guard/floorplate frame was replaced with a two-piece arrangement somewhat like that adopted for the Winchester Model 70 several years earlier. The trigger bow is of cast aluminum, while a small steel flange supports the front guard screw. The floorplate is also cast aluminum, mortised at the front like the Enfield, but held in place at the rear with a machine screw which threads into a flanged bushing in the stock.

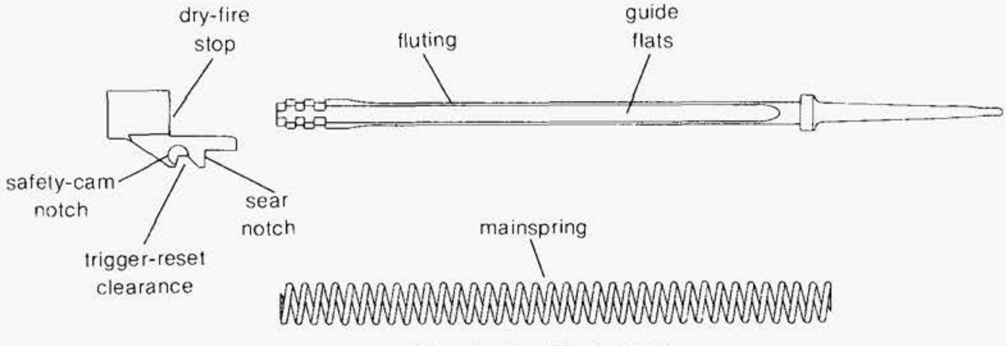
While advertised as an easily detachable floorplate, it was in truth even more awkward than the previous military pattern. The floorplate still fell off (rather than hinging) and in addition a screwdriver was now required to remove a screw which could also be very easily lost. About the only redeeming feature of this new arrangement was a reduction in weight due to the aluminum parts. Overall, in fact, Remington succeeded very well in finally trimming the massive Enfield action down to a reasonable weight. It actually finished up a couple of ounces lighter than the Winchester Model 70 action.

Remington engineered in a very desirable improvement on the Enfield latch-type bolt stop. The problem with this Mauser-originated pattern had always been the need for three hands to operate—one to hold the rifle, one to pull out the latch, and one to remove the bolt. In the Model 30, Remington had made an even worse mess of this system, but corrected it all in the 720. The same type ejector and bolt stop flange is used, but now nicely fitted into a push-button arrangement for easy one-handed operation.

The least obvious but perhaps most interesting modification involved a dramatic change in the lock mechanism. Striker fall was reduced almost in half from that in the Model 30. Thus it had been progressively shortened from almost 3/4 in. in the Enfield to about 1/2 in. in the Model 30 to 1/4 in. in the Model 720.

Since the Enfield had a considerable excess of striker energy, the reduction in firing pin fall in going to the Model 30 was no problem. It was, however, in the Model 720, and despite a moderately stiffened mainspring, the original units failed to give sufficient indentation for reliable ignition. Mike Walker, who had by then taken over Remington's rifle program, designed a new mainspring for the 720 with quite heavy coils (.058 in.). This new mainspring, combined with the skeletonized firing pin inherited from the Model 30, and the new short fall, gave surprisingly fast lock time, considerably faster than in the Winchester Model 70 Speed Lock, and in fact one of the fastest bolt action ignition systems ever designed. When Remington went to the new 721/722 series after the war, they actually eased back on lock time a bit by going to a longer striker fall.

The Model 720 came standard with a single-stage trigger. The term is misleading as it was little more than a home-workshop version of the Enfield unit, and the result fell far short of the superb override trigger of the rival Winchester Model 70. The single-stage pull in the 720 is achieved by simply eliminating the initial hump and using a screw through the trigger



Remington Model 720, firing pin assembly

piece to regulate slack. This idea was far from original but had always been poor, since the resulting mechanism cannot effectively combine a crisp single-stage pull with an adequate safety margin, as can the override trigger. A double-pull version was also offered as an option on the 720, and considering the inherent limitations of the direct-pull mechanism, it was probably the better choice.

The fact that the Model 720 lacked an override trigger reflected one of the disadvantages of building a modified military rifle and also indicated the reluctance on Remington's part to really commit the 720 at that point as the basis for future Remington sporting rifles. The technology was certainly available at Ilion, as Crawford Loomis had employed an excellent version of the override trigger a couple of years earlier in the Model 37 rimfire target rifle.

SUMMARY

The Model 720 was the last pure *classic* bolt-action rifle designed by a major U.S. arms company. It was certainly the finest Remington arm of this type. Had it not been discontinued, and instead been further evolved in its few weak areas such as the trigger and the floorplate arrangement, it may well have become the finest classic bolt action ever built. The following summarizes its strong and weak points:

Strong points:

1. Strong locking and camming.
2. Mauser-type extractor.
3. Integral bolt handle (and backup lug).
4. Direct-acting safety.
5. Positive and controlled ejector.
6. Fast lock time.
7. Excellent bolt stop/ejector unit.

Weak points:

1. Springfield breech and gas handling.
2. Converted military trigger.
3. Awkward floorplate configuration.

REMINGTON MODEL 720

Dimensions

OPERATING

Extraction: set-back—.12 in.
leverage—9 to 1

Chambering (two-phase):
1st (from cams) cam-forward—.10 in.
leverage—9.5 to 1
2nd (from angled locking faces) cam-forward—.03 in.
leverage—80 to 1

Bolt rotation—90.5°

Bolt travel—4.71 in.

Operating forces: bolt lift—5.5 lb.
bolt turndown—4 lb.

Force to close bolt when single loading—4.5 lb.

Cock-on-opening: .253 in.
mainspring compression
proportioned as follows:
opening—.203 in.
closing—.050 in.

IGNITION

Firing pin travel: at impact—.183 in.
dry-fired—.253 in.

	Loomis mainspring	Walker mainspring
Lock time (ms.)	3.0	2.6
Impact velocity (ft./sec.)	12.0	13.6
energy (in.-oz.)	50.9	65.0
impulse (oz.-sec.)	.71	.80

Striker/firing pin hole diameters—.072 in./.082 in.

RECEIVER

Overall length—8.84 in.

Length of loading/ejection port—3.54 in.

Ring diameter—1.355 in.

Barrel/receiver threads: designation—1⅛-10 (square form)
engagement—.6 in. (6 threads)

Recoil lug: width—1.17 in.
height—.36 in.
bearing area—.36 sq. in.
clearance from magazine—.87 in.

Guard screws: front — ¼ x30
rear — ¼ x30

Scope mounting provisions—none

BOLT

Lug shear area—.399 sq. in.

Lug bearing area—.102 sq. in.

Bolt diameter—.697 in.

Lug heights: left (top)—.144 in.
right (bottom)—.122 in.

Bolt face: type—semi-recessed
depth—.045 in.

MAGAZINE

Length—3.40 in.

Depth: front—2.05 in.
rear—2.28 in.

Capacity —5

WEIGHT

Receiver group—20.6 oz.

Bolt group—13.9 oz.

Magazine/floorplate group—8.6 oz.

Total action weight—43.1 oz.

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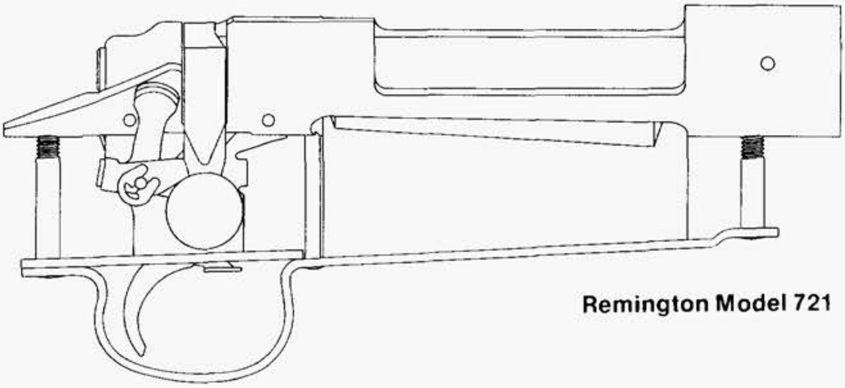
Remington Models 721/722, 725 and 700

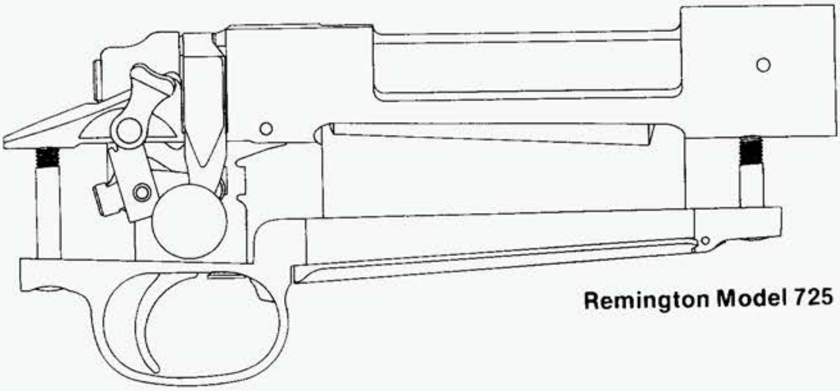
Remington took advantage of the forced disruption in the manufacture of sporting arms caused by World War II and embarked on what they called the reconversion and modernization program. A new high-power sporting rifle was the pilot project.

When M1903A3-A4 production contracts were completed in 1944, all effort was focused on development of an entirely new bolt action, rather than preparing to resume production of the Model 720. The design team was headed by Mike Walker and its goal was to update both design features and manufacturing techniques.

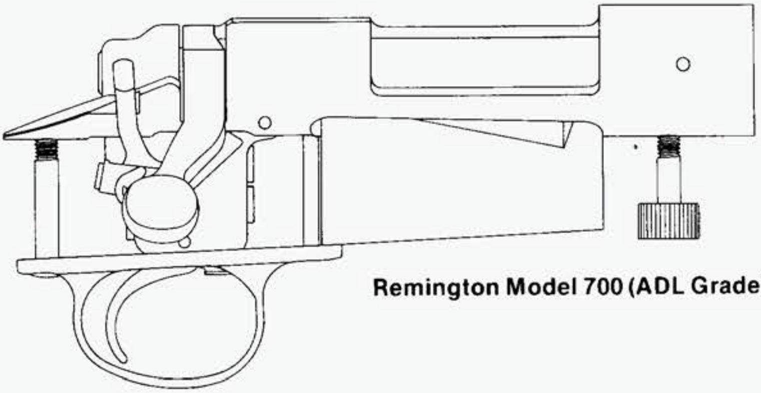
The application of new manufacturing concepts entailed a very heavy investment in special machine tools, and it was initially projected that a 15,000 unit per year sales would be necessary to turn a profit on the new rifle. Thus, considering Remington's pre-war experience in trying to compete against Winchester's Model 70, this was actually much more of a gamble than it now seems in retrospect.



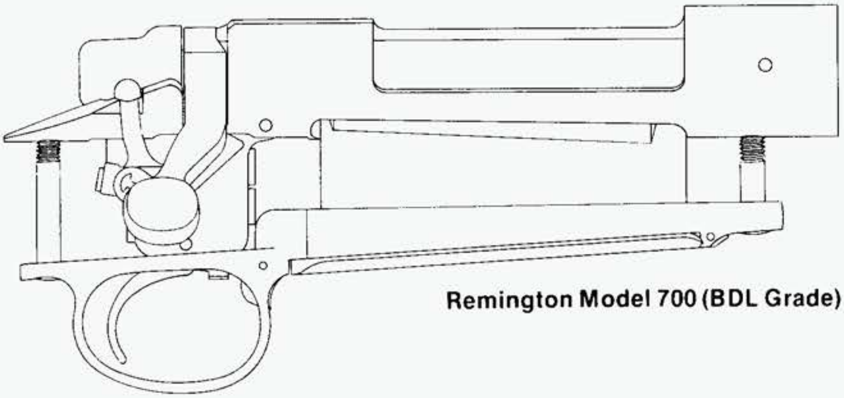
Remington Model 721



Remington Model 725



Remington Model 700 (ADL Grade)



Remington Model 700 (BDL Grade)

The development phase at Ilion was long and intensive, but the results more than justified the effort. The end-product was the first truly modern centerfire bolt action. It had many pace-setting features such as the cylindrical receiver, fabricated bolt, shrouded breech, and internally mounted extractor and ejector. Manufacturing efficiency was also years ahead of its time.

The manufacturing of a pilot run of the new rifle, designated the 721, began early in 1947. Because of the many new processes involved, however, a number of production problems arose, delaying the beginning of full-scale manufacturing until mid-1948. The production of a shorter version, the 722, followed a few months later. The Model 722 was identical except for length, with separation between the ring and bridge .85 in. less. Remington introduced both in January, 1949. They initially sold well above expectations—more than 50,000 the first year—far exceeding the total combined sales of the Model 30/720 series.

From the start, engineering was the strong point of the 721/722. Strength, performance, and accuracy, combined with low cost, created the initial market. These attributes were not due only to the design and manufacturing methods for the new action, but were also due in part to the use of a new button process for rifling the barrel developed at Remington during the war (U.S. Patent 2,383,356 issued Aug. 21, 1945 [M. H. Walker]).

Remarkably favorable writeups from the sample rifles distributed for evaluation in 1948 were also extremely helpful to sales. In fact, these were so favorable that Remington could not resist compiling them into a publication with the snappy title "What the Experts Say About the New Remington Models 721 & 722 Big Game Rifles."

The weak point of the new rifle was looks. Trim, but plain, it lacked the slick lines of the Winchester Model 70 and many Mauser-based sporters. Deluxe versions were eventually offered: The 721AC/722AC and 721B/722B in 1953, the 721BDL/722BDL in 1955, and finally the 725 in 1958.

Of these variations, only the Model 725 involved any actual rework of the action. It had a hinged floorplate, a slightly swept-back and blued bolt handle, a nicer trigger shoe, and a modified safety. It was the only link in the 721/722, 725, 700 series not designed under Mike Walker. He was at that time developing Remington's line of cartridge-driven construction tools and animal stunners, and the 725 project came under Wayne Leek's department and was headed by Clark Campbell, who later wrote *The '03 Springfields.*

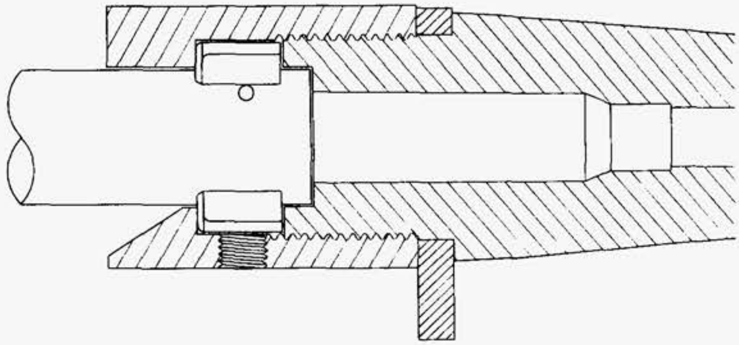
The 725 never sold well (about 10,000 total) and a gradual but continuing sales decline of the entire series forced a basic restyle in 1962. Redesignated the Model 700, the new rifle came in two grades, an ADL grade essentially replacing the 721/722 and a BDL grade offering the deluxe stock and floorplate configuration of the 725.

Appearance of the action was modified primarily by means of a more streamlined tang, a swept-back and checkered bolt handle, and a Model 725-like trigger guard assembly. The overall effect was very successful, and the Model 700 has been for some years now easily the most popular American-made bolt action.

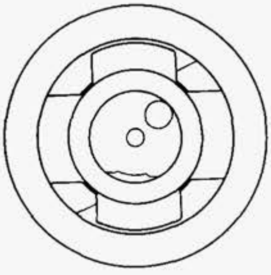
There have since been two more revisions of the action, in 1968 and 1974. Both were less extensive than those of 1962, and the changes are detailed later in the chapter. Like all Remington firearms, the Model 700 is manufactured at the huge Ilion works, where, because of a policy to make critical-strength parts from solid steel, can be found the most extensive and sophisticated machining processes in the commercial firearms industry.

Remington's Model 700 breech recesses the cartridge base into a deeply counterbored bolt head, which in turn fits a counterbore in the barrel. These are surrounded by the receiver ring and, as so often noted in Remington advertisements, the cartridge head is encircled by three steel rings. More important than the resulting structure itself, the close bolt-nose fit can confine case-head failure and limit gas escape back into enlarged, and thus more susceptible, portions of the receiver.

The basic *counterbored breech* was neither an entirely new idea with this Remington action—the Japanese had it in the military Type 38—nor is it exclusive with Remington today—it is currently used by several others, including Weatherby and BSA in England. Remington did bring it into



Remington Model 700, breech



Remington Model 700, front view

widespread commercial use and developed it to its purest form. Because of the solid Remington bolt-face rim, and the deep (about .15 in.) and close-fitting nature of its bolt-nose encirclement, there probably isn't a more effective turnbolt shrouding system.

Almost any engineering solution involves compromise, however, and Remington's solid cartridge-head encirclement is no exception. The tiny internally-mounted C-spring extractor involved lacks an integral purchase. The retaining lip thus made necessary within the bolt head increases bolt-face counterbore depth beyond an optimum figure, and cartridge-head protrusion from the chamber is on the high side, far more than in a Mauser, and even exceeding that in the Springfield rifle. Starting with a bolt counterbore of about .150 in., and adding clearances, tolerances, and the chamber-mouth radius, protrusion approaches minimum cartridge web thickness. Thus careful barrel fitting is particularly important in this rifle.

It might be interesting to closely examine the Remington bolt-nose fit. Clearance is approximately .010 in. (.010 in. diametral clearance and .010 in. end gap) which restricts, but normally, of course, could not seal gas escape. Under extreme pressure, however, this breech can actually obturate. This is detailed in Remington's breech patent (U.S. Patent 2,585,195 issued Feb. 12, 1952 [M. H. Walker]) describing tests where pressure expanded the bolt-nose rim into the barrel to seal off everything but the firing pin hole. This expansion, while damaging the bolt nose, nevertheless protected the rest of the action under conditions completely wrecking all other actions tested. To verify that the shroud accounted for this strength, Remington also tested and destroyed several Model 721 prototypes modified to eliminate the barrel counterbore.

It's perhaps logical then to consider fitting the breech even tighter to increase effectiveness. Analysis will show that the normal Remington tolerances are already close to minimum from a production standpoint. But would it be useful to *lap-in* the counterbore of a custom barrel for more positive bolt-nose support? Probably not. The factory rifle is already susceptible to dirt. Nothing puts a Model 700 out of action faster than a loose grain of powder or a primer fragment entrapped in the counterbore. A much closer fit would certainly impair reliability. Some custom benchrest rifles built on the Remington action are fitted closer than factory practice, and sometimes even a loose bristle from a bore brush will jam these.

While Savage pioneered the application of cylindrical receivers to centerfire rifles back at the end of World War I, their Model 1920 required a separate soldered-on rear tang. Design of the Remington 721/722, on the other hand, allowed the use of a cylindrical receiver as is. The receiver starts out as a simple length of barstock and is machined with speed and precision on automatic machines, with minimum material waste. The following briefly traces current manufacture of the Model 700 receiver:

The pre-cut chrome-moly bars are first turned and faced, then drilled and broached to form the bolt-well and raceway channels. Next the tang and ejector port are roughed out on a bank of horizontal mills. Most subsequent machining is then accomplished on two huge Tri-Ordinate units. These are three-dimensional cam-controlled machining centers with multiple stations.

The receiver is clamped to the Tri-Ordinate rotating table and automatically indexed under a series of machining heads. Six receivers undergo progressive operations at the same time. Every two minutes the table indexes, one receiver is off loaded and replaced by a fresh one. The off-loaded receiver is deburred and fed immediately to the second Tri-Ordinate on the next cycle. Each receiver goes through the same set of cutters, yet once both stations get going, in effect it takes only two minutes for twelve different operations.

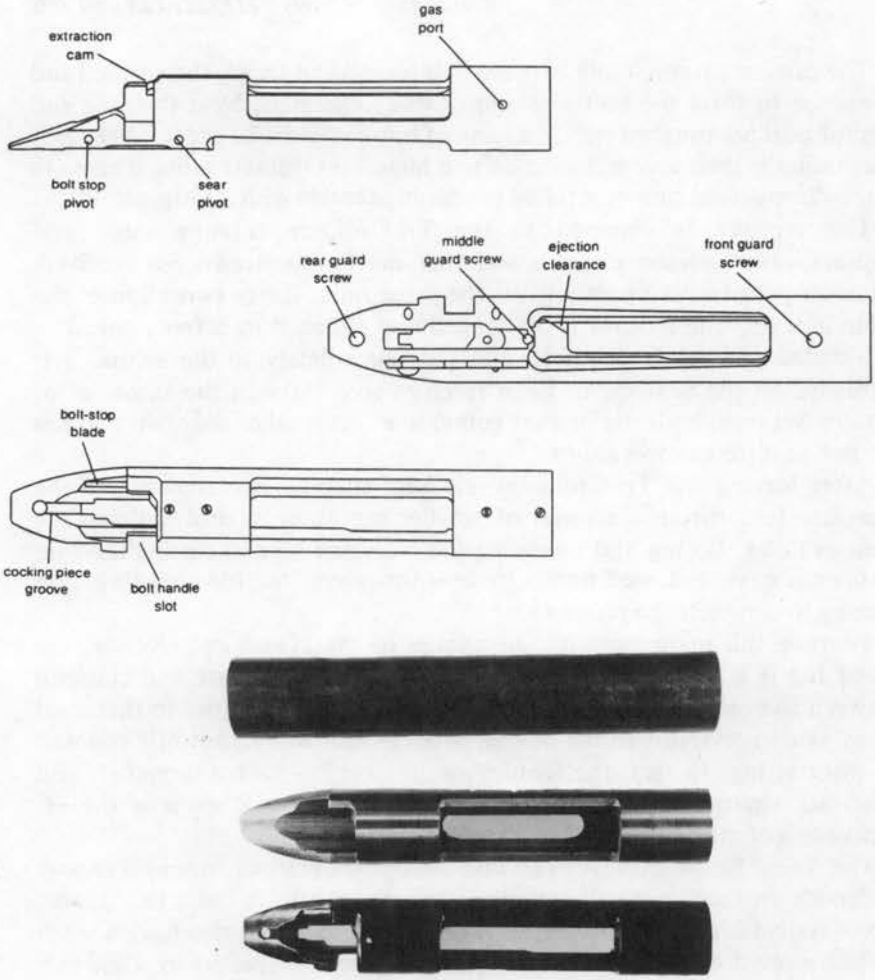
After leaving the Tri-Ordinates, external shaping is complete and the receivers feed through a series of smaller machines to drill and tap the various holes. Boring and threading the receiver ring and cutting the cam inclines is next, followed finally by heat treatment, tumble-polishing, and blueing to complete the process.

To take full manufacturing advantage of the cylindrical receiver, the recoil lug is a separate part blanked from heavy steel plate and clamped between the receiver and barrel. This bracket system, similar to that used many years previously in the Savage Model 1920, is mechanically equal to an integral lug. In fact, the Remington bracket has such a large face and generous separation from the magazine cavity that it exceeds the effectiveness of most integral lugs.

The round Remington receivers also strengthen performance by a greater underside surface to distribute support in the stock. A basic two guard-screw system is used, although the 721/722 and 700 ADL also have a small middle screw for the trigger bow. It has long been suspected by some that the Remington rifle perhaps gained slightly in bedding and accuracy from this small middle screw. Benchrest experience with third guard screws generally does not support this conclusion, however, and the latest Remington factory target rifles substitute a wood screw to intentionally avoid the effect.

The accompanying drawings show the pre-'74 Model 700 receiver. The 721/722 differed only in a higher-walled and wider rear tang and a slot in the bridge resulting from the early method used to mill the magazine opening. The receiver was again modified in 1974, although the difference this time is less readily apparent. The right siderail is .050 in. higher to form a rail for a new bolt-guide system. The left side is also raised an equal amount, thus actually further strengthening the already rigid receiver.

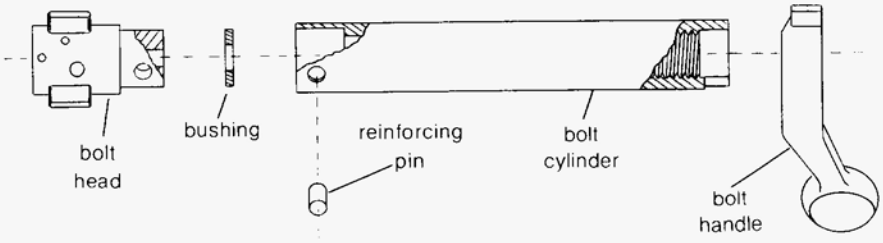
The bolt is brazed together from five pieces. The cylinder and bolt head are machined from chrome-moly barstock, while the handle is investment


gas port
extraction cam
bolt stop pivot
sear pivot
middle guard screw
ejection clearance
front guard screw
rear guard screw
bolt-stop blade
cocking piece groove
bolt handle slot

Remington Model 700
Receiver in process

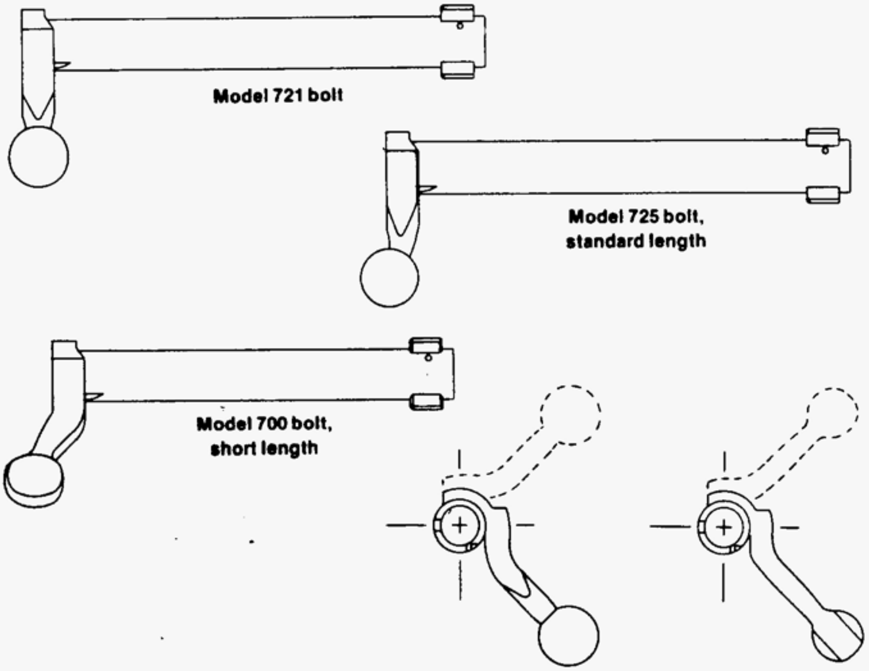
cast. Sandwiched behind the bolt head is a heavy steel washer to support the ejector and act as a stop when snapping the firing pin. A heavy dowel fits cross-wise into one side of the bolt-head joint to reinforce it and index the parts during brazing.

The dowel assures that the lugs will seat, even if the brazed head joint fails. This is a very remote possibility, however, as both joints are furnace-brazed at high temperature with copper alloy, forming a bond of extreme strength (and also one which is unaffected by subsequent heat treatment). Following brazing, the bolt handles are tested in a pneumatic press and then punch marked under the shank for verification.



This built-up bolt construction achieves economy without sacrificing locking strength, since the lugs remain part of the bolt head. In fact, like the receiver, the cylindrical patterns permit exceptional accuracy and precision in manufacture. The resulting overall concentricity of receiver, bolt, and barrel is superior to that generally possible with more classic forged bolts.

The restyled bolt handle represented the main appearance change in the Model 700. While the 721/722 bolt handle was curved for a low-mounted scope, it was not swept back, it had a smooth round knob, and it was bright chrome plated. The Model 700 handle is swept back, has an oval knob checkered on top and bottom, and is blued, giving a more refined quality look to the whole action.



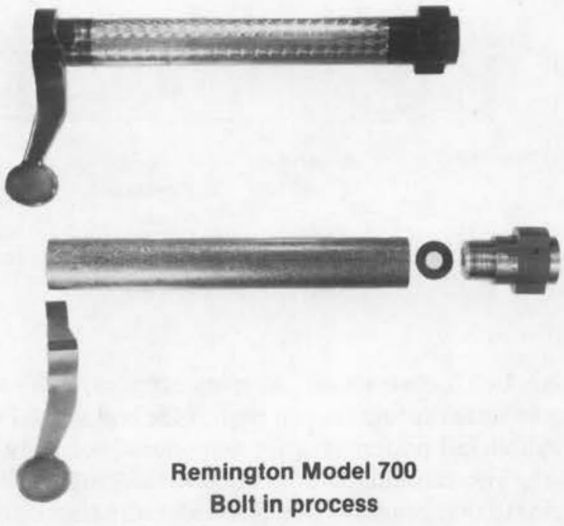
Model 721 bolt

Model 725 bolt, standard length

Model 700 bolt, short length

Remington Model 721, bolt-handle profile

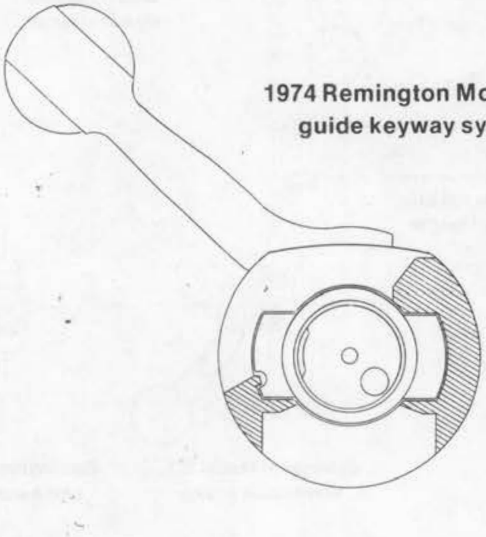
Remington Model 700, bolt-handle profile



Remington Model 700
Bolt in process

Since 1962, the bolt has undergone several additional changes. Engine turning was added in 1968. In 1974, two changes occurred. About 1/8 in. of the rearward handle sweep was eliminated in order to help avoid barking the knuckles on heavy-recoil versions. A guide-rib system was also added, functionally similar to that on the new Winchester Model 70 and Savage 110. While it does reduce angular bolt play, the effect is relatively small, since the Model 700 already gave solid and smooth operation. In contrast, both the 1964-version Model 70 and the original Model 110 badly needed help, and thus benefited significantly from the guide-rib idea.

The two massive locking lugs set behind the bolt rim, leaving a protruding nose to fit the barrel counterbore. These lugs turn 90° to vertical as the bolt



1974 Remington Model 700,
guide keyway system

locks. About 30° represent initial bolt play and camming, leaving a full 60° for lug/seat locking engagement. The internal ejector permits a solid left locking lug, thus giving a perfectly balanced support for the breech with large lugs of identical dimensions, one of the strongest locking patterns ever employed in a sporting arm. The brazed-on bolt handle enters a receiver notch to serve as a backup.

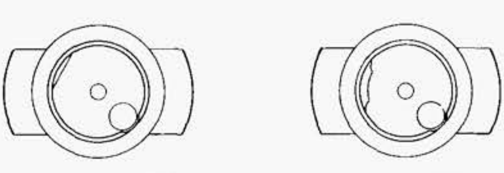
The 721/722 extractor (U.S. Patent 2,473,373 issued June 14, 1949 [J. D. Howell]) was a small cold-forged spring fitted inside the bolt-face counterbore. It expanded into an internal groove in the bolt-rim walls, with elongated holes at each end to permit easy removal and replacement. While the arrangement appears to be very simple and straight-forward, the shape and dimensions of both the internal groove and the extractor ring are in fact very critical for proper operation.

John Howell had originally designed this extractor for a new series of automatic and slide-action centerfire rifles which never got into production. In its original form, the extractor was to be machined. This proved infeasible for mass-production, however, and another member of the 721/722 design team, Homer Young, is credited with saving the design by devising a method of coining the lip on the extractor ring.

This claw or lip was only a small straight ridge, giving a very shallow purchase on the case rim. Nevertheless, there were initially some impressive claims as to its extracting power (300 lb. versus 150 lb. for a "conventional" extractor) based on the proposition that its frontal containment allows the formation of a "compression strut" which can release only by shearing through the cartridge rim.

The extractor was modified extensively for the Model 700. While it still fits an internal groove in the bolt head, it is now riveted at one end. The other end remains free, of course, to permit expansion during locking. Both versions easily engage as the cartridge head presses into the bolt-face counterbore during bolt closure, eliminating noticeable hesitation.

The new extractor also has a better shaped claw, now gripping about one-eighth of the cartridge rim—still light by Mauser standards, but reliable. Finally, the claw is oriented closer to the right locking lug in order to lower the ejection trajectory and thus help avoid hitting low-mounted scope tubes. At the same time, empty cartridges in some calibers can now bind in the right raceway on the way out.



Model 721/722 *Model 700*

Extractor-ejector arrangements

The 721/722 adopted the plunger-type ejector of the M1 service rifle, now a very common item in commercial bolt rifles. The plunger is spring loaded against the cartridge base, while a cross pin retains it in place.

By avoiding a slotted bolt rim, this type ejector allows a more perfect breech closure than possible with a Mauser ejector. It also has drawbacks. During bolt retraction, empty cases are not controlled by the bolt, and the necks scrape along the receiver-ring interior. When they clear, there is likewise no control, and all cases are ejected at maximum velocity, a problem when attempting to collect them for reloading. During locking, the strong off-center pressure from the plunger can slightly misalign the chambered round. Generally, these are objectionable only in a varmint or benchrest rifle, and are easily overcome by eliminating excessive tension in the ejector spring.

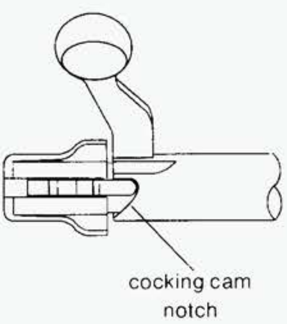
The magazine is a Mauser staggered-column type, of sheet-metal construction throughout with the exception of a cast stainless-steel follower introduced into both the ADL and BDL grades in 1974. There are several floorplate patterns. The 721/722 used a simple bent steel strap, a rather spartan and unattractive system. The ADL grade Model 700 has a small cast aluminum trigger bow attached by the rear and middle guard screws, and a recessed steel bushing for the front guard-screw escutcheon. The stock is only partially routed out, thus leaving a wood floor under the cartridge box. Only the Model 725 and BDL grade Model 700 have a hinged floorplate, supported by a one-piece aluminum trigger guard/floorplate frame.

Other than two small gas ports of questionable significance, one in the receiver ring and the other in the bolt head, there is little protection against any powder gas which might enter the action. A rearward-blown firing pin is stopped when the mainspring goes solid. This allows it to move rearward past full-cock about 1 in. in the 722, about 5/8 in. in the present short action (because of a longer mainspring introduced in 1968), and 1 1/4 in. in the standard-length version.

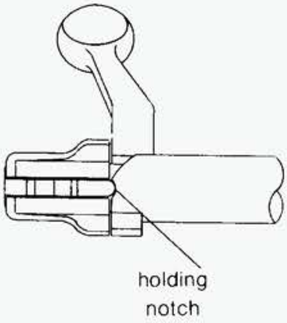
Obviously limited emphasis has been placed here, at least compared to some other actions like the Mauser M98 or Weatherby Mark V. Remington's approach of a strong breech, without an equally effective backup system, reflects a perhaps valid philosophy of attacking trouble at its source, rather than making provision to minimize its effect. Nevertheless, others have gone further, and both contribute to the ultimate safety factor. Remington engineers really don't argue the point, and have for some time, in fact, been working to perfect a shrouded bolt sleeve for the Model 700 which is acceptable not only mechanically, but also from the economic and styling viewpoints, not as easy a task as it may seem.

Hardened cams on the bolt and receiver perform all operating functions as the bolt handle is raised and lowered. Like the Mauser, the cams are not only powerful, but also have sufficient engagement to avoid any hesitation during either the opening or closing cycles.

The bolt sleeve (or *bolt plug* in Mauser's and Remington's terminology) threads into the bolt to support the mainspring and guide the firing pin. Indexing is accomplished by the holding notch, thus eliminating the need for a separate Mauser-like locking device.



Uncocked

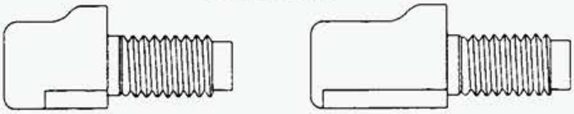


Cocked

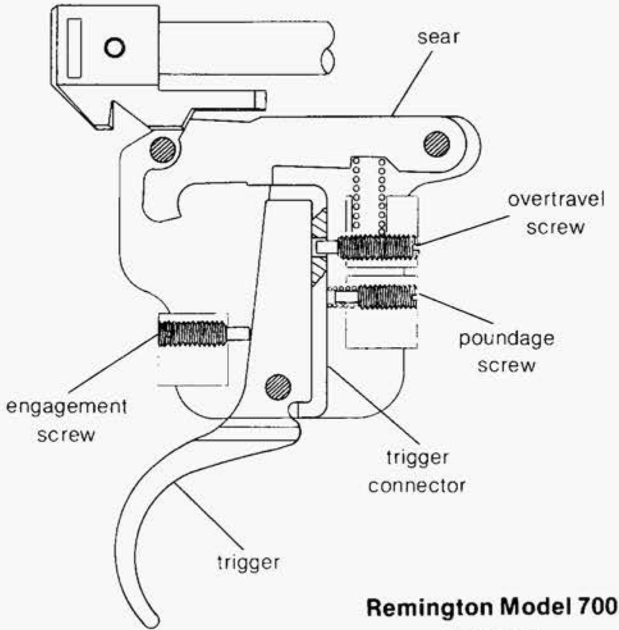
Before 1968, the cocking piece always protruded from the bolt sleeve. The current bolt sleeve is 1/4 in. longer to recess the cocking piece after firing. This change was not motivated by styling, but rather a problem involved in exporting rifles to Australia, where one test of proof involves letting the firing pin down on a primer and then striking the bolt sleeve with a hammer.

The trigger is a single-stage override type, but a somewhat sophisticated variation which results in one of the best performing triggers made. The entire firing unit, comprising the trigger and safety assemblies, is covered under U.S. Patent 2,514,981 issued July 11, 1950 (M. H. Walker and P. R. Haskell). It is fully adjustable, although the action must be taken out of the

Bolt sleeve



Pre-'68 *1968*



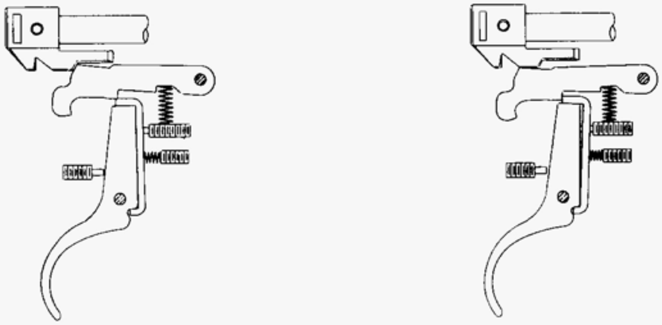
Remington Model 700, trigger

stock. Our sample rifle had a 3 lb. and .012 in. letoff, with .017 in. overtravel, exceptional performance for an out-of-the-box standard grade rifle.

The secret to this level of performance in a reasonable-cost assembly primarily involves a unique *connector* piece resiliently mounted on the trigger. Normally, unless the trigger ledge is perfectly sharp and true—an almost impossible thing to both produce and retain in service—the sear begins breaking before the edges are fully clear, resulting in a spongy and imprecise release. The Remington *trigger connector*, a hardened steel strip sandwiched between the trigger and sear, allows precise trigger function without perfect surfaces and a sharp and clean release without perceptible overtravel.

The trigger connector is held against the trigger piece by a small spring and thus is capable of moving forward separately. Trigger pull displaces the connector until the sear begins breaking downward. The overtravel-stop pin then blocks the trigger, while the connector, which has a small clearance hole, continues forward until completely out of the sear's path.

This basic resilient-trigger concept was first developed for Remington back in 1939 by John Sweany (U.S. Patent 2,341,299 issued Feb. 8, 1944) and employed in the Model 37 rimfire target rifle (Series 1939). The same resilient action was achieved in this original version, although the arrangement and shape of the parts were very much different.



Remington Model 700, trigger

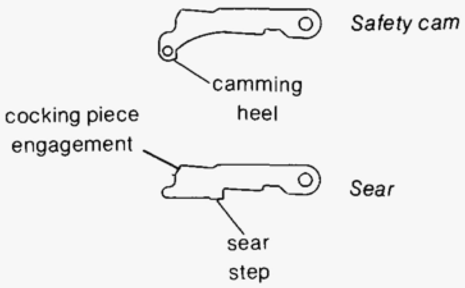
The resilient-mounted connector has added purpose in this particular Remington trigger. Unlike most more recent swing-down designs, the Model 700 sear pivots at the front. It thus swings forward as it drops, requiring an increasing clearance. Were it not for the connector piece, added trigger movement would be required on that account for a clean release.

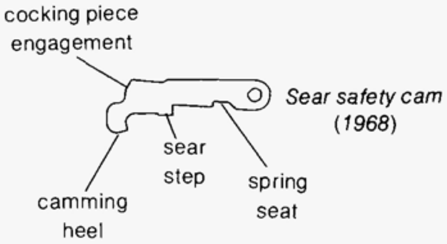
Two cross pins fix the trigger assembly to the receiver. The forward pin is also the sear pivot, and the rear pin the bolt-stop pivot and sear stop. A housing encloses and supports the remaining parts, with an opening to show sear engagement.

The Model 700 and 721/722 triggers differ in detail. Shape of the trigger shoe improved in the 700 version. The 721/722 shoe was thicker and ungrooved. The shoe (and trigger guard) were also set back for the sweep of the Model 700 bolt handle. Housing construction also improved. The 721/722 housing was folded sheet metal, with the adjusting screws working in partial threads cut into the opposing walls. This structure was dropped in 1962 (although reintroduced a couple of years later in the Model 600 series). The Model 700 uses the 40-X housing, a very precise and solid affair with the side plates riveted to three support blocks, each block housing an adjusting screw.

In 1968, the sear also changed. It previously comprised two side-by-side pieces. The left piece was called the *safety cam* and was controlled by the safety. With the safety off, it moved free and so wasn't part of the trigger function. The right-hand piece was actually the *sear*, engaging the trigger connector but not the safety.

Except for using inexpensive blanked parts, this split setup segregating the safety and trigger functions into two independently moving pieces served no purpose, and in fact the narrow parts allowed greater wear. In 1968, Mike Walker substituted the present one-piece version which combines the functions of the previous two parts. It is a chrome-plated sintered-metal part, precision formed to eliminate the machining needed on the



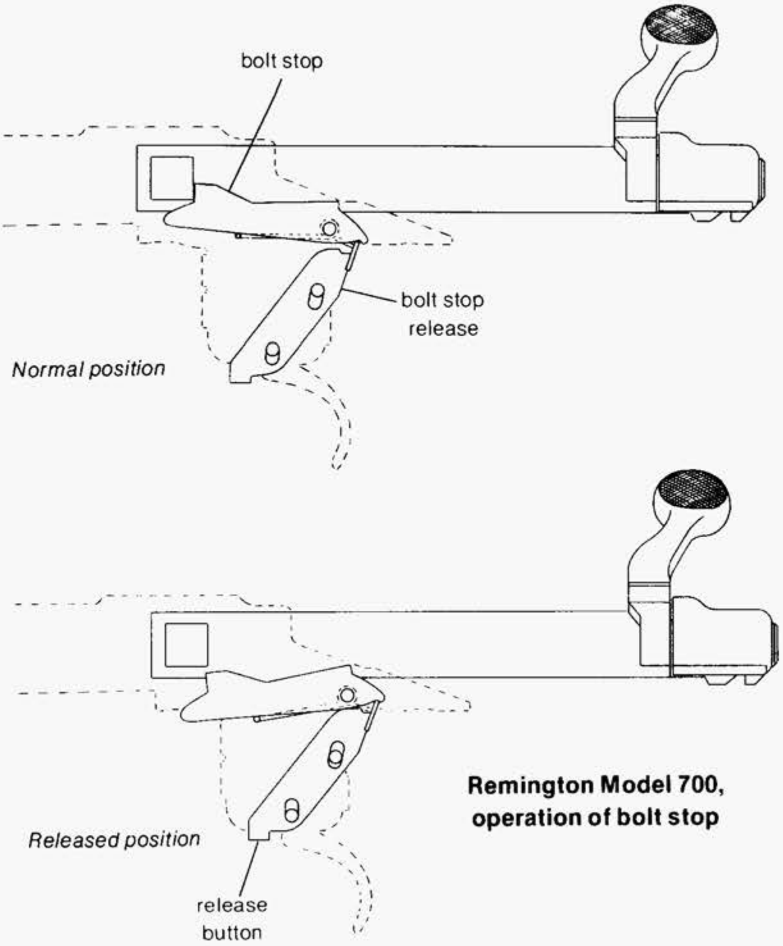


working surfaces of the previous blanked parts, and giving full-width contact between the sear and trigger connector.

It may seem suspiciously obvious that the two-piece system never had much functional purpose. This was, in fact, known at the time. As originally designed by Mike Walker, the sear was a one-piece blanking. During the final review of the design by Remington's patent attorneys, however, a possible infringement of the sear-safety design of Winchester's Model 52 (U.S. Patent 2,191,521 issued Feb. 27, 1940 [H. L. Crockett]) was discovered. This occurred after considerable quantities of *pilot-lot* rifles were already in the warehouse awaiting shipment, and thus understandably caused some consternation. Phillip Haskell, who had recently joined Remington from the Aberdeen Proving Ground, was given the unenviable task of quickly finding a solution which not only avoided infringement, but equally important, caused the least possible disruption to the design and manufacture of the rifles. After several weeks of studying the drawings and the patent claims, he came up with the two-piece idea. While it may not appear a brilliant solution on the surface, it required modification of only the sear itself, and thus accomplished the intended purpose extremely well. The production line was modified quickly and easily, and all the warehoused rifles were uncartoned and returned to the factory for rework at minimum cost.

The bolt stop is a pivoted blade which rises up to block the left raceway. It is actuated by a small spring (a coil spring in the 721/722 and now a torsion spring) and the bolt is removed by pressing a small tab in the trigger bow which in turn pushes on the rear of the bolt stop blade to pivot its front tip down flush with the raceway floor. This configuration allows a clean receiver exterior without the undesirable expedient of using the trigger for the bolt stop.

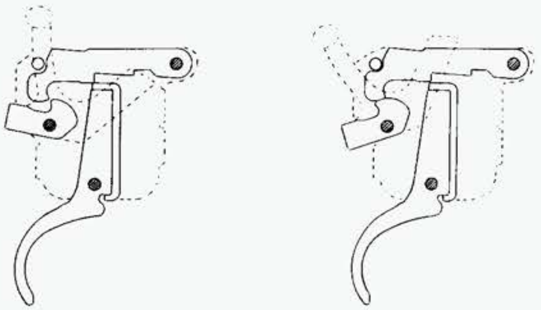
The safety is a two-position sear type. It is a U-shaped stamping pivoted to the trigger housing. On one side is formed a bolt-lock blade and thumbpiece (integral in the 721/722 and a more solid looking welded-on



Remington Model 700, operation of bolt stop

part in the 700) and on the other a camming radius. A spring-loaded ball sandwiched between the safety and trigger housing detents in each position.

Rocked rearward, the bolt-lock blade rises to lock the bolt from turning while simultaneously the sear is cammed upward. The sear is cammed completely off the trigger connector, so that the trigger is free to reset if necessary. This situation is analogous to that in a direct safety. If the sear were only blocked, and the trigger pulled, it might drop enough to prevent trigger reset, particularly if tolerances or wear had created extra play in the system. Safety release could then accidently discharge the rifle.



Fire position *Safe position*

Remington Model 700, operation of safety

Operating on the sear, while in theory possibly slightly less positive than directly on the firing pin assembly, is nonetheless totally effective and far superior to merely blocking the trigger. This is because engagement between the sear and cocking piece far exceeds that between the sear and trigger, often by a factor of 10 or more. Operation of the Remington safety is also exceptionally easy, and in fact this is perhaps the best combination of positive action and convenient and silent operation yet devised.

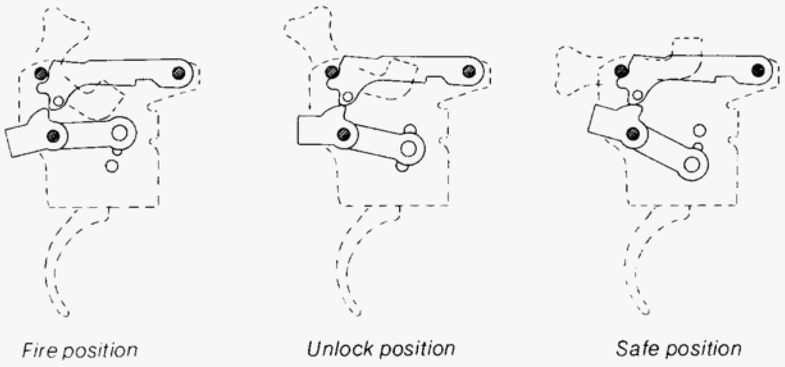
A subtle design advantage helps account for this performance. The Remington safety operates with relatively little cam displacement and thus a high effective leverage. Less force is needed and it is smoother and easier to operate than a Mauser bolt-sleeve mounted safety.

This is possible due to a more precise working location, which can be analyzed as follows: With the action cocked, the receiver-mounted trigger unit locates the cocking piece. Required safety-cam displacement largely depends on how precisely the safety is located relative to this *set* cocking piece. Any uncertainty requires adding extra length to the cam angle, thus diminishing its effective leverage.

A bolt-sleeve mounted safety lacks a precise relationship with the cocking piece. While physically adjacent, relative positioning between the two depends on too many intermediate parts and dimensions (safety/bolt sleeve, bolt sleeve/bolt, bolt/receiver, receiver/trigger, and finally trigger/cocking piece). Thus, though only a few thousandths cam-back is actually required, many times that is used to assure functioning with all tolerances. Because the Remington safety, on the other hand, pivots directly on the trigger housing and operates on the sear, all critical locating holes are drilled on the same part, virtually eliminating tolerance errors.

The Model 725 had its own safety, with a third position to allow opening the bolt with the sear locked. Great pains were taken to simulate the appearance and feel of the Enfield/Model 30/Model 720 safety. Not only was a cast thumbpiece used, but it was pivoted to the receiver and given almost a full half-turn operating arc. It continued to cam the sear as in the 721/722, however, and thus the extra pivot point on the receiver required a small compound gear system to simultaneously control movement of a separate cam piece and bolt-lock blade. Because of the reversed rotation which results, the cam sector is essentially a mirror image of that in the 721/722. The whole layout, which is shown in the drawings, is really quite simple. But it did require numerous detail and machining modifications, not only to the safety and trigger assemblies, but to the tang area of the receiver itself. Thus it fit in poorly with Remington's post-war emphasis on design standardization.

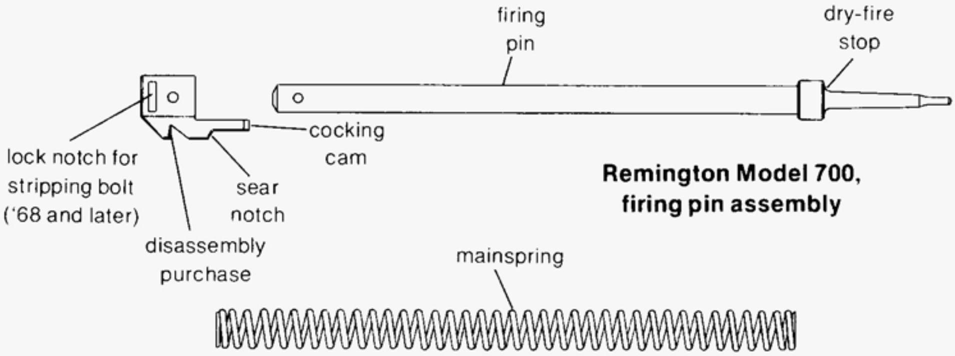
The firing pin is a one-piece rod with a pinned-on cocking piece. This attachment with a small (3/32 in.) cross pin contrasts with the Mauser system of six heavy locking lugs. The difference reflects the manner of controlling dry firing. In the Remington, the solid mainspring flange drives into the bolt-head bushing for this purpose, subjecting the cocking-piece


Fire position

Unlock position

Safe position

Remington Model 725, operation of safety



Remington Model 700, firing pin assembly

joint to relatively little impact. In the Mauser, the cocking-piece joint absorbs the entire impact.

The only significant change in the lock mechanism came in 1968 when a more powerful mainspring setup was added to the short-version Model 700. Since the wire and coil diameters were fixed by the bolt interior, free length was extended about an inch with the addition of six more coils. The new setup thus operates under more suppression, giving a higher average driving thrust to the firing pin. While the reason for the change was to boost impact effect, it also speeded lock time and, because of a greater solid height, gives a little better control of firing pin snap-back in the event of a punctured primer.

SUMMARY

Remington was the first major arms company to apply the technical advances of the Second World War to sporting arms. The 721/722 not only had functional advantages, but equally important, allowed true mass production. Yet unlike some later post-war designs, it was a careful blend of the traditional and the modern and was basically made up of solid machined parts, not fit together from a maze of stampings. Its original *tinny* aspects involved trim like the trigger guard and magazine, which were later upgraded as the design evolved through the years.

Many purists, however, never accepted Remington's abandonment of the strict classic bolt action. These critics were even more unhappy sixteen years later when Winchester finally made a similar move.

Perhaps most remarkable is the fact that the Model 700 remains one of the most modern of Mauser derivations. In recent years there have appeared any number of seeming challengers, but most stray too far in one way or another from Mauser principles, and thus eventually fall by the wayside.

The following summarizes the strengths and weaknesses of this action:

Strong points:

1. Strong breeching and locking.
2. Positive and convenient safety.
3. Fully adjustable trigger.
4. Strong bedding configuration.

Weak points:

1. A shallow grip in the 721/722 extractor, improved in the 700 but now difficult to repair if damaged.
2. Blind magazine in 721/722 and 700 ADL, and sheet-metal trigger guard and floorplate in 721/722.

REMINGTON MODELS 721/722, 725 and 700

Dimensions

OPERATING

Extraction: set-back—.09 in.
leverage—8.5 to 1

Chambering: cam-forward—.13 in.
leverage—8 to 1

Bolt rotation—90°

Bolt travel: short action—3.99 in.
standard action—4.84 in.

Operating forces: bolt lift—4.5 lb.
bolt turndown—7.5 lb.

Cock-on-opening; .275 in.
mainspring compression
proportioned as follows:
opening—.234 in.
closing—.041 in.

IGNITION

Firing pin travel: at impact—.213 in.
dry-fired—.275 in.

	short action (pre-'68)	short action	std. action
Lock time (ms.)	3.0	2.6	3.0
Impact velocity (ft./sec.)	13.4	15.2	13.7
energy (in.-oz.)	67.9	87.2	79.7
impulse (oz.-sec.)	.84	.96	.97

Striker/firing pin hole diameters—.075 in./.078 in.

RECEIVER

Overall length: short action—7.85 in. (8.04 in. with recoil bracket)
std. action—8.70 in. (8.89 in. with recoil bracket)

Length of loading/ejection port: short action—2.39 in.
std. action—3.24 in.

Ring diameter—1.355 in.

Barrel/receiver threads: designation—1$\frac{1}{16}$-16
engagement—.69 in. (11 threads)

Recoil lug: width—1.10 in.
thickness—.185 in.
bearing area—.50 sq. in.
clearance from magazine—1.59 in.

Guard screws: front—¼x28
middle—8x36
rear—¼x28

Scope mounting—6x48 screws

BOLT

Lug shear area—.428 sq. in.

Lug bearing area—.107 sq. in.

Bolt diameter—.697 in.

Lug diameter—.987 in.

Bolt face: type—counterbored
depth—.149 in.

MAGAZINE

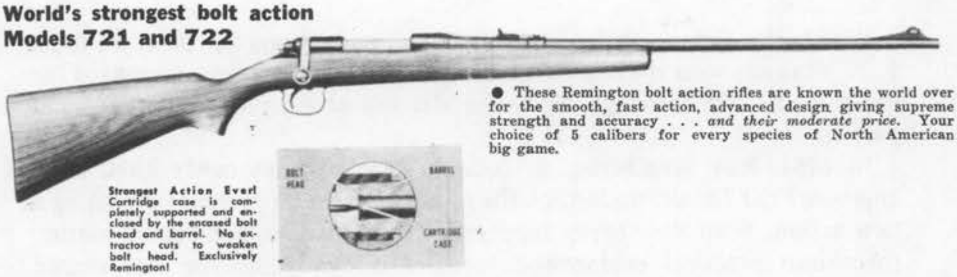
Length: short action—2.85 in.
standard action—3.70 in.

Depth: front—1.94 in.
rear—2.08 in.

Capacity: .222 Remington (.376 in. head)—5
.308 Winchester (.473 in. head)—4
.375 H&H (.532 in. head)—3

WEIGHT

	short action	standard action
Receiver group (w/recoil bracket)	18.4 oz.	19.2 oz.
Bolt group	12.2 oz.	13.6 oz.
Magazine/floorplate group (ADL grade)	4.6 oz.	5.3 oz.
Total action weight	35.2 oz.	38.1 oz.


World's strongest bolt action
Models 721 and 722

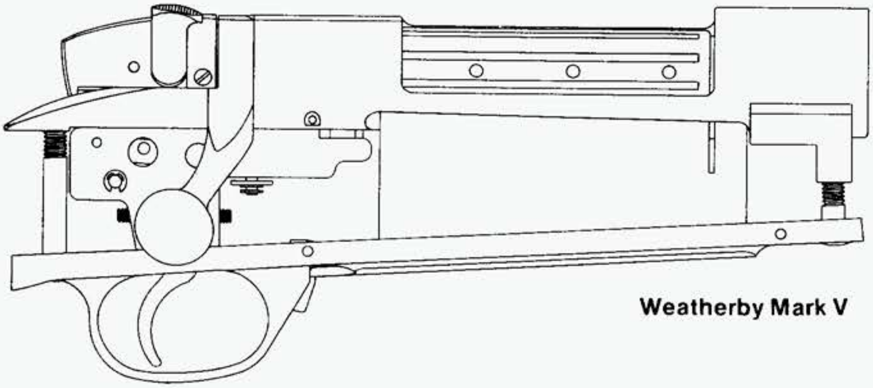
● These Remington bolt action rifles are known the world over for the smooth, fast action, advanced design giving supreme strength and accuracy . . . *and their moderate price.* Your choice of 5 calibers for every species of North American big game.

Strongest Action Ever! Cartridge case is completely supported and enclosed by the encased bolt head and barrel. No extractor cuts to weaken bolt head. Exclusively Remington!

Early 721/722 ad (1952). Note that only the bolt and barrel are credited with cartridge enclosure. Only in 1954 did Remington's marketing department decide that the receiver ring constituted a third enclosure.

10

Weatherby Mark V



Weatherby Mark V

Weatherby Deluxe Rifles were built for many years on other actions. F. N. Mausers were the basic action. Schultz & Larsen actions were used for the oversize .378 cartridge, while the Mathieu action provided a left-hand pattern.

In 1954, Roy Weatherby, in collaboration with his newly hired chief engineer Fred Jennie, undertook the rather ambitious project of designing a new action. With Weatherby supplying the basic ideas, and Jennie putting them into practical engineering form, a *design* prototype was brazed together at South Gate in a few months time.

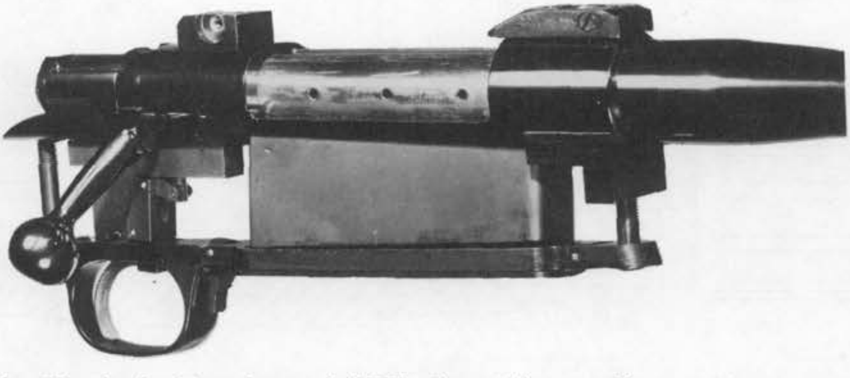
This rather crude first attempt was then sent East to the Mathewson Tool Co. for development of what was supposed to be a final or *manufacturing* prototype. The result was the *Weatherby Experimental*, shown in the accompanying photographs. It came back as really little better than a copy of the original, thus forcing Weatherby at that point to either abandon the project or finish development in-house. The latter course was chosen, in retrospect a rather fortunate turn of events, as Fred Jennie certainly proved to be an exceptionally able firearms designer.

Far more work lay ahead than either Weatherby or Jennie had anticipated, and final development of the action to the point where it could be profitably manufactured took several years. Many changes evolved during this period, perhaps the most striking a large but streamlined bolt sleeve which finally brought this rather massive action into balance. Overall styling of the Mark V turned out so well, in fact, that it has been widely copied in recent years, one of the surest measures of design success.

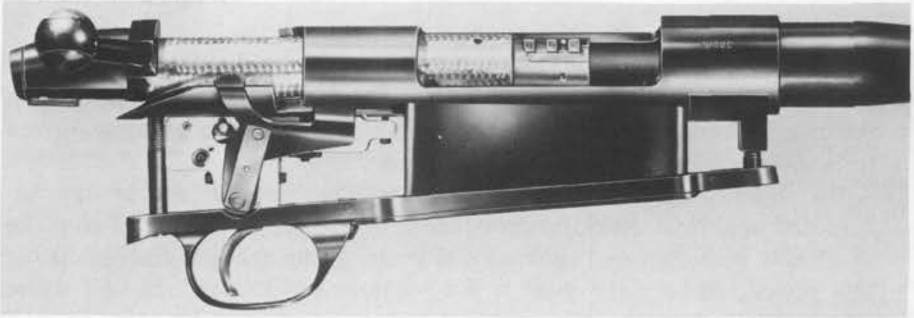
Testing and evaluation of the Mark V prototypes was finished by 1958, at which time patent application was filed. The original application was divided at the request of the Patent Office. The overall action is covered by U.S. Patent 3,013,355 issued Dec. 19, 1961 (R. E. Weatherby) which still ended up a very broad and rambling document. The second patent (3,024,559 of March 13, 1962 and again with R. E. Weatherby listed as the sole inventor) was a more specific document covering the design of the safety.

A parallel manufacturing effort was initially undertaken. At South Gate, actions were put together using investment-cast parts from Precision Founders, Inc. of San Francisco. Simultaneously, tooling was being set up for manufacture with forged parts under a one-year contract with J. P. Sauer & Sohn of Eckernförde, West Germany.

Sauer production got underway in 1959. Favorable labor and exchange rates at that time made it far less expensive, and California production was



The Weatherby Experimental (1955). The styling problems with the early bolt sleeve shapes are evident in this photograph.

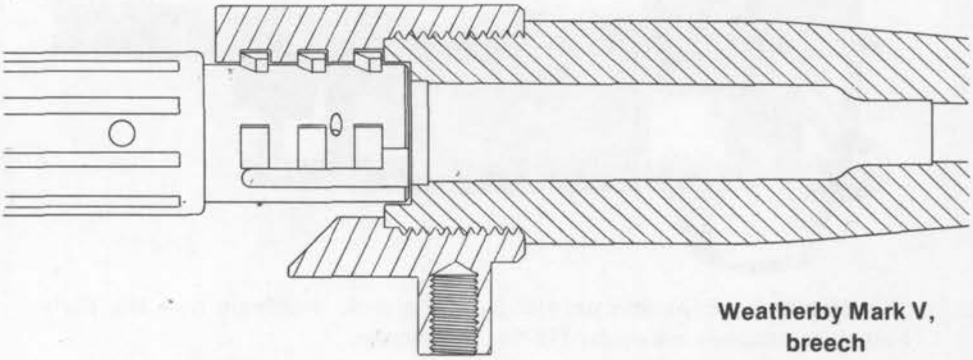


Original Mark V. Note unfluted bolt, checkered bolt knob, sear safety, and two-piece bolt sleeve.

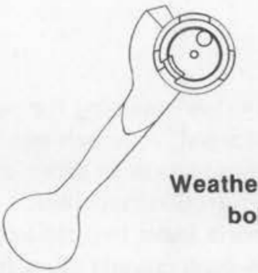
discontinued as soon as there was sufficient inventory. In all, only about four or five thousand actions were made in California.

By the late 1960s, the situation had changed considerably. Rising German production costs forced Weatherby to begin looking for new manufacturing facilities. After checking many possibilities, including some domestic firearms companies, an agreement was negotiated with the Howa Machinery Co., Ltd. of Nagoya, Japan. Tooling at Howa began in 1969, with the first production units arriving in South Gate in 1971. West German production phased out in early 1972, so about a year's overlap existed, with both Sauer and Howa-made Mark V's being supplied.

The Mark V has a counterbored breech similar to the Remington Model 700, with the bolt head shrouded by the barrel. Directly comparing the two, a more optimum bolt-face depth (.12 in. compared to .15 in. in the Model 700) and walls which are not undercut, favor the Weatherby. The Model 700 has the advantage of an internal extractor.



Weatherby Mark V, breech

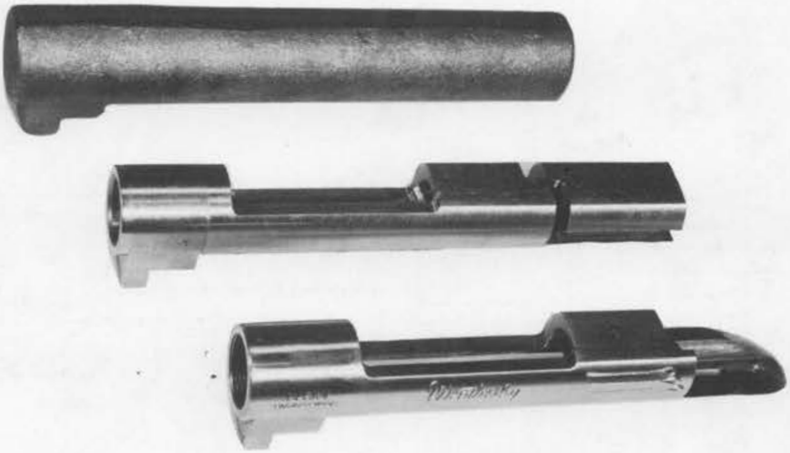


Weatherby Mark V,
bolt face

When first introduced, the Mark V invoked quite an advertising war. Remington had been advertising the 721/722 for many years as the "World's strongest bolt action." In late 1958, Weatherby took out full-page advertisements featuring the Mark V as the "WORLD'S *STRONGEST* ACTION." After about a year of this, things slacked off. The claims continue today, but much lower key.

The present Mark V receiver is a nickel-chrome-moly forging. It is a pure cylinder, except for a massive recoil lug and bedding pad combination under the receiver ring, which eliminates much of the manufacturing efficiency of a cylindrical receiver. The forging is lathe-turned up to the receiver ring, but the remaining exterior then requires a complex series of milling operations.

The California-made receivers (and bolts) were X-rayed investment castings. The same basic alloy was used, and according to Weatherby, strength was not a problem. The cast parts, however, did suffer a high

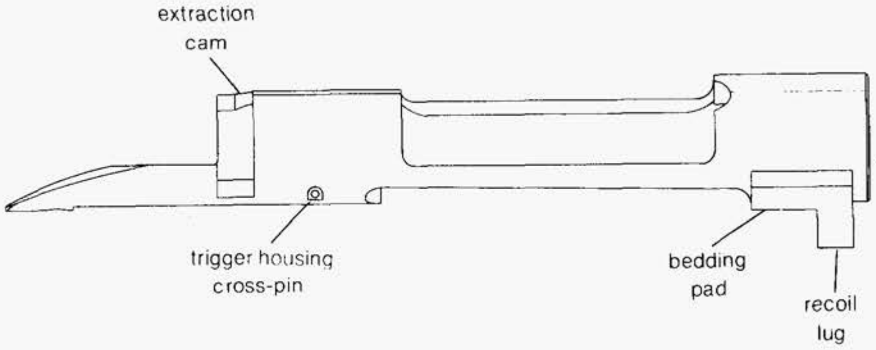


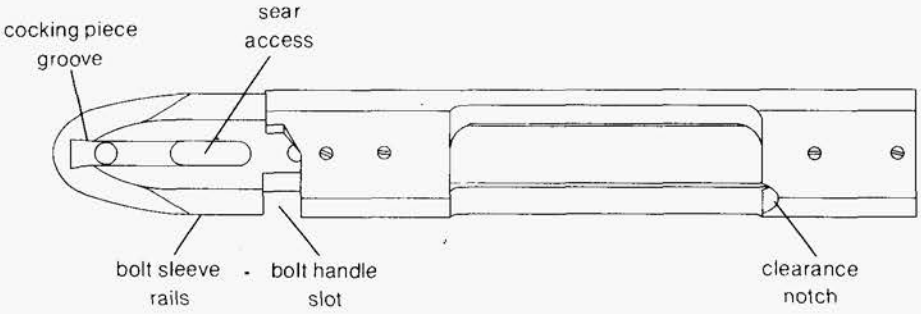
Weatherby Mark V
Receiver in process

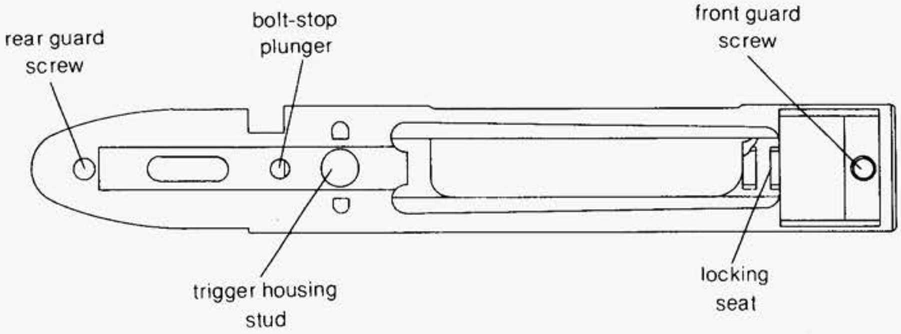
rejection rate from tiny porosity flaws marring the polished surfaces. Both the Sauer and Howa parts are forged, although machining processes have changed considerably. Howa production is more automated, employing several multiple-function tape-controlled machines.

The loading and magazine ports leave two rails connecting the receiver ring and bridge. These magnum-sized cutouts allow little metal on the right side and the sturdier left rail provides most structural rigidity. Except for nine small inward-protruding lug seats in the receiver ring, the receiver interior is a simple cylindrical bore, without the usual raceway channels.

The Mark V recoil lug is both thick and large-faced. The long Weatherby magazines, however, leave little stock depth behind it, and consequently the factory stocks are glass-bedded.


extraction cam
trigger housing cross-pin
bedding pad
recoil lug

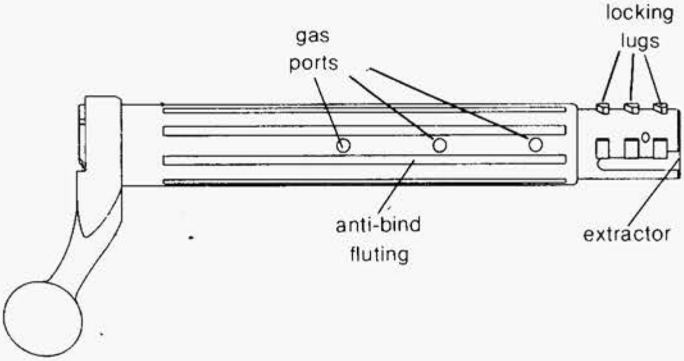

cocking piece groove
sear access
bolt sleeve rails
bolt handle slot
clearance notch

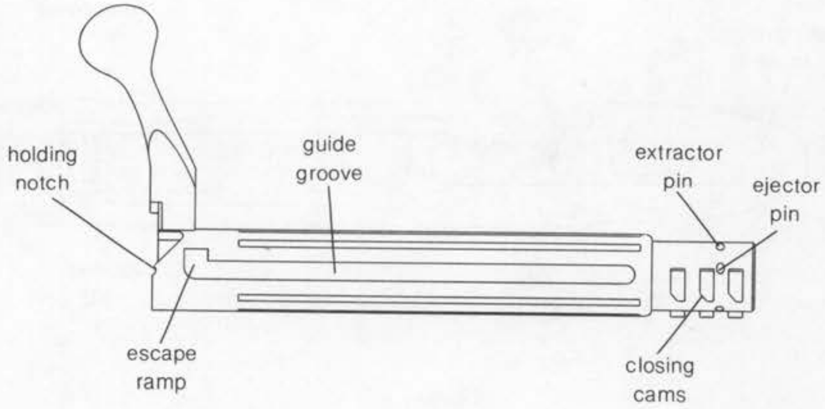

rear guard screw
bolt-stop plunger
front guard screw
trigger housing stud
locking seat

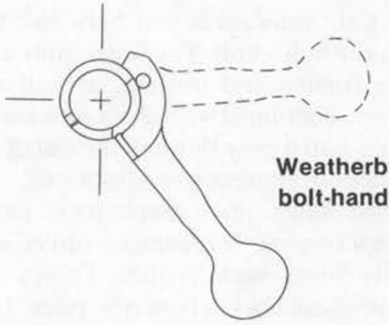
The massive forged bolt has more or less become the Mark V trademark. Its handle is integral, a strong but costly feature seldom used in designs of recent years. The California-made cast bolts had a smooth bolt body and cast checkering on the bolt knob. The Sauer bolts added eight shallow relief grooves to reduce friction and binding, as well as improve appearance. Early Sauer bolts also continued with checkered knobs, but hand-filed. This expensive procedure lasted only through the end of the first year's contract, at which time the smooth contour was substituted.

As shown in the Sauer photograph (next page), the bolt handle is straight in the rough forging. It is contour-turned on a tracing lathe before cold-forging to its swept-back profile. Except for the early pre-1958 prototypes, the bolts have always been one-piece. Long-range plans include the possibility of a fabricated bolt in the future; however, a 1972 magazine report of production of three-piece Mark V bolts at Sauer was in error.

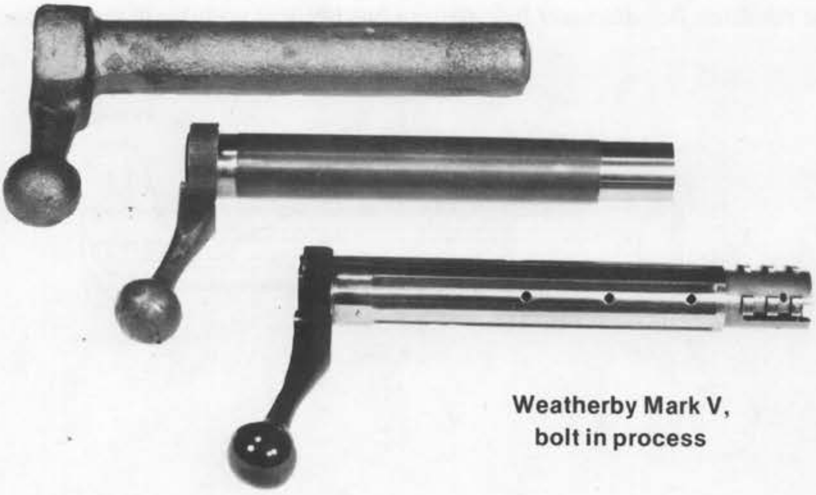
The locking lugs are formed by grooving and channeling the bolt head. The resulting *full-diameter* bolt pattern has become popular in recent years,


gas ports
locking lugs
anti-bind fluting
extractor


holding notch
guide groove
extractor pin
ejector pin
escape ramp
closing cams



Weatherby Mark V, bolt-handle profile



Weatherby Mark V, bolt in process

thanks in large measure to the prestige of the Mark V. Several technical advantages are attributed to it, most at least partially valid. The non-protruding lugs do eliminate a relatively expensive operation of broaching long and deep raceways within the receiver. Also, the shoulder formed on the bolt can be located to help confine gas escape to the receiver ring, although this is not necessarily advantageous, and is not done in the Mark V.

Other advantages often claimed are a smoother operation with less play and tendency to bind, and a strengthening of the action. The first is true only when compared to some examples of the Mauser family. The Mark V is very smooth in operation, but not noticeably superior to actions like the Winchester Model 70 or Remington Model 700.

Concerning strength, bolt-body diameter plays a minor role, since strength in a front-locked action is formed in the bolt head and receiver ring. Of course by eliminating the lug clearances within the receiver ring, non-protruding lugs do allow a thicker-walled structure, less susceptible to expansion. Theoretically, greater rigidity is also possible, since no metal is removed for raceways along the sides of the receiver. The Mark V's extra large bolt and magnum-sized loading and magazine ports, however, remove so much of the connecting rails that, if anything, its midsection ends up weaker than many protruding-lug actions.

The Mark V's locking system is in itself an interesting subject. Weatherby has long claimed that the nine lugs give almost double the shear area of conventional two-lug actions. This is an error, stemming from a mix-up between engineering and marketing. Where multiple lugs achieve advantage is in bearing area, usually a more critical aspect of bolt design anyway. While a double-area claim is stretching things a bit, the Mark V is very strong—only appropriate for its huge .378 and .460 cartridges.

Yet nine lugs are not necessary to get the Mark V's bearing strength. The Remington Model 700, probably the strongest two-lug bolt, achieves equal contact with two. Why, then, so many lugs, with the attendant machining expense?

The answer traces to the way the Mark V was developed. Fred Jennie worked around certain more or less fixed criteria set down by Roy Weatherby. One was the full-diameter bolt idea. Thus, to keep the bolt diameter to a reasonable size, and yet capable of handling the large-head cartridges for which it was intended, the lugs ended up quite shallow (less than half the height of Mauser-type lugs). Another criterion was a short bolt lift, which again limits the contact of each lug. With slightly less than 60° of rotation, little contact width remains on each lug after subtracting the necessary camming phase. Even with three lugs spaced around the bolt head, each has such a narrow locking face that the end result is still negative.

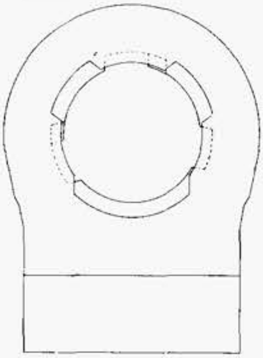
The more lugs spaced around the bolt head, and thus the shorter the bolt rotation, the less efficient the camming/bearing strength relationship. This can be shown by some simplified considerations, noting first, however, that the amount of bolt rotation devoted to camming is a function of the cam strength desired, not the number of lugs. For the sake of argument, 30° of camming can be assumed.

With a two-lug array and 90° rotation, 90° -30° or 60° is potentially available for lug bearing contact. So with two lugs, a total of 2 x 60° = 120° contact-arc is possible. With a three-lug array and 60° rotation, only 60° -30° or 30° rotation is potentially available for lug/seat contact. So for the three lugs, a total of only 3 x 30° = 90° contact-arc is possible. As the number of lugs increase, the total bearing arc possible continues to diminish. The size of the cams and the actual detailed layout can be juggled somewhat to modify these numbers, but not the basic principle.

The preceding factors limit potential bearing strength, and had only a single three-lug array been used in the Mark V, set-back problems with the huge Weatherby Magnum cartridges were possible. By breaking the lug array into three rows, one behind the other, this relatively small available bearing area was tripled. In other words, the small and shallow Mark V lugs are subdivided to bolster what might otherwise be an insufficient bearing strength, as opposed to the conventional approach of two relatively large and deep lugs.

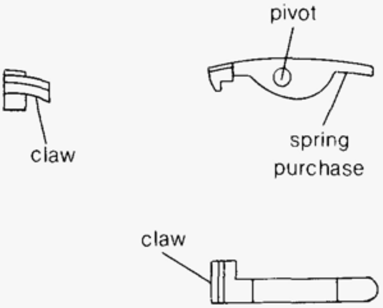
The Mark V has a 56° bolt turndown, the final 32° accomplishing lug/seat locking engagement (in comparison, the Remington Model 700 has a 60° locking phase). The forged bolt handle enters a receiver notch to act as a safety lug.

A frequent criticism of multiple-lug actions is that machining tolerances preclude a perfect fit, leaving an uneven distribution of load. This, however, is not necessarily significant, providing initial fit is close, as it is in the Mark V. It improves with loading and wear, and any lugs lacking full contact will pick up long before stresses get out of hand. In any event, few two-lug actions actually leave the factory with even bearing, and the problem in both types of actions is more often distortion in heat treatment, not a lack of machining precision.



Weatherby Mark V, lug/seat layout

The Mark V extractor recesses into the bolt head. A flared claw grips almost one-sixth of the cartridge rim, with a pivot and coil spring arrangement to provide resiliency for engagement during bolt closure. The ejector, located on the opposite side of the bolt-face counterbore, is a spring-plunger type.

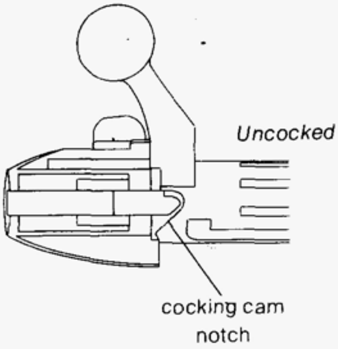


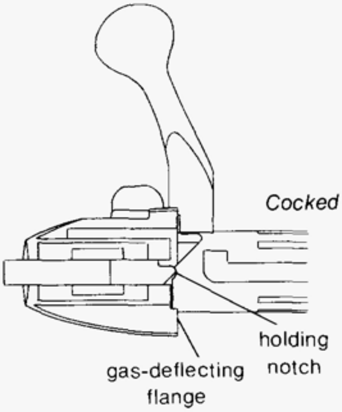
Weatherby Mark V, extractor

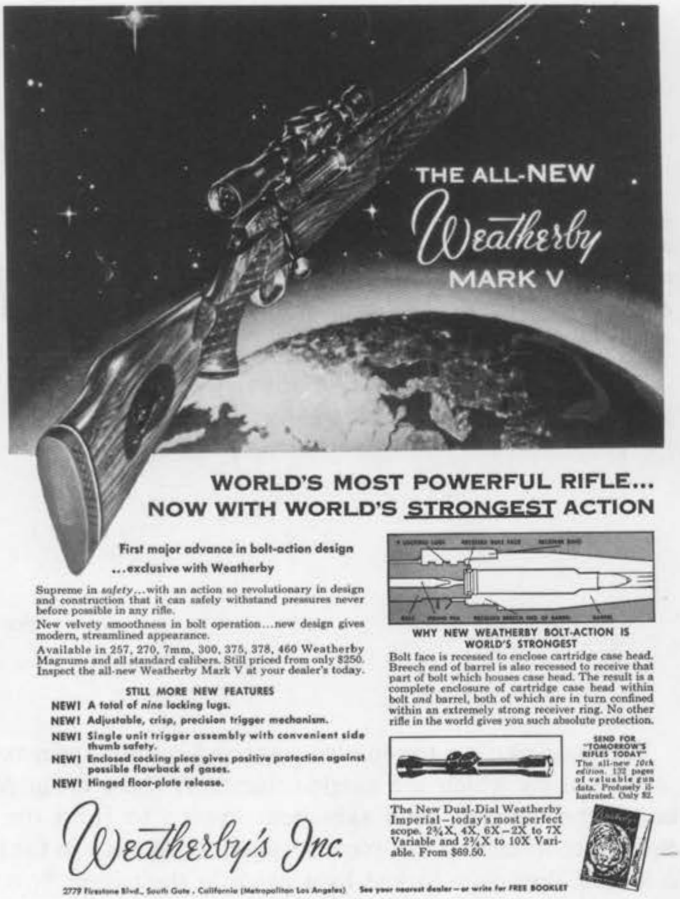
The magazine is a top-loaded staggered-column type, except the .378 and .460 versions which are single-column. A sheet metal cartridge box fits under the receiver, with tabs bent inward to form the guide lips. The floorplate frame is a one-piece steel unit (zinc alloy in the Howa units) with a hinged floorplate locked by a catch in the trigger bow. Lugs under the follower hold the assembly together when emptying the cartridge box.

The Mark V has an efficient gas-handling system. The receiver ring, which is protected by the barrel shroud, is very strong. Besides a lack of gas ports, its structure benefits from the shallow lugs which allow extra-thick walls. At the rear, the bolt sleeve flanges off the bridge as in the Mauser M98.

Gas entering the firing pin hole is handled in an equally thorough manner. The firing pin, which is milled down at its flange to minimize any gas-piston effect, is blocked at the rear by both an entrapped steel ball and the solid rear wall of the bolt sleeve itself. In addition, the bolt has three 1/8 in. diameter ports. Finally, any remaining flow is shrouded by the solid bolt sleeve. In all, a thorough and positive gas-handling arrangement.







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NEW! Single unit trigger assembly with convenient side thumb safety.
NEW! Enclosed cocking piece gives positive protection against possible flowback of gases.
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First Mark V ad (1958) where Roy Weatherby displayed his usual reticence and modesty.

The cam systems are Mauser in principle. However, with less than two-thirds the usual bolt rotation, they are dimensionally restricted and the Mark V lacks the smooth and powerful camming of most two-lug bolts.

Cam displacement during opening and closing is little more than 1/16 in. While there is adequate leverage, the short cam-forward distance on closing (as a comparison, cam-forward is 1/8 in. in the Remington Model 700 and 1/4 in. in the Mauser M98) creates a weakness in the Mark V operating cycle. Resistance to closure, caused by the extractor, begins before the bolt is ready for turndown.

The locking lugs remain trapped between the seats at this point and the chambering cams can't engage. To get the bolt started down, the cartridge must first be pressed past the extractor and into the bolt-face counterbore, requiring a smart shove forward. While not difficult, this introduces a hesitation into the closing cycle. By comparison, bolt closure in a Winchester Model 70 or Remington Model 700 is a smooth continuous sweep, without hesitation preceding cam engagement.

The three-lug array lies at the root of this problem. With the smaller arcuate width of each lug, less surface is expendable for cams. To retain an angle giving good mechanical leverage, the cams are cut shallow, and thus must move up close to battery position to engage. Were they ground away more on the sides to engage sooner, the resulting cam angle would give less leverage. Cutting them deeper on the same angle would cause a loss of the bearing faces. A boxed-in situation thus exists, with improvements in one place made at the expense of another.

The bolt sleeve is a large but gracefully styled one-piece investment casting, threading into the bolt to guide the firing unit and closed off at the rear for a gas shield. A hole drilled through the top of its threaded nose houses a steel ball which indexes the firing pin and limits its rearward movement.

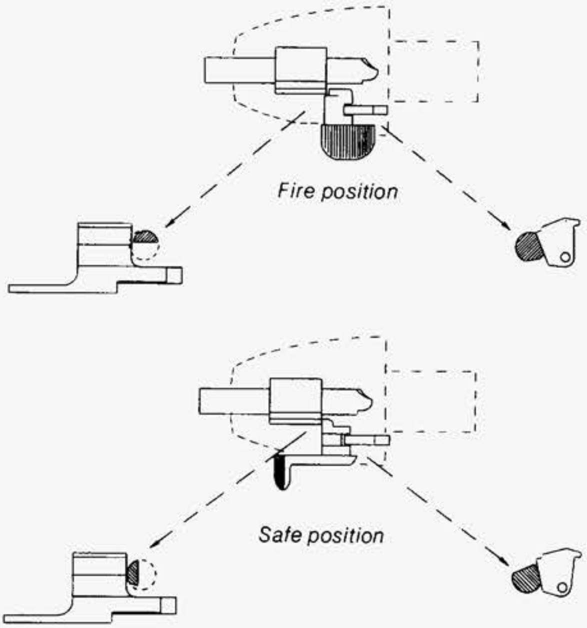
The Mark V prototypes had a two-piece bolt sleeve with a separate cap forming the rear shroud. It was driven off the bolt sleeve by the firing pin in last-minute gas blowback tests, and rather than take any chances, the solid pattern was adopted before production got underway. The two-piece unit can be spotted in early publicity photographs.

The original Mark V safety was a sear type mounted on the trigger housing and similar to that on the Winchester Model 52 and Remington Model 721/722. It was covered by U.S. Patent 3,024,559 issued March 13, 1962 (R. E. Weatherby). Several other patents had already been issued on the same basic sear safety, including the one to Winchester (2,191,521 of Feb. 27, 1940 [H. L. Crockett]) and Remington (2,514,981 of July 11, 1950 [M. H. Walker and P. R. Haskell]). This is not really uncommon, as U.S. Patents issued through the years have varied greatly in value. Careful examination of the allowed claims show many patents to constitute little more than very specific adaptations of previous inventions, as was certainly the case here.

While basically a very sound approach, the cam in this first Weatherby safety was part of a soft stamped side plate and was subject to rapid wear. Additionally, some customers did not like the location and operating feel of the thumbpiece. Thus, rather than hardening the sideplate, Fred Jennie replaced the whole system in 1962 with an Enfield-like direct safety mounted on the bolt sleeve. (Going back to the development period, it is interesting to note that the first prototypes also had a direct bolt-sleeve mounted safety, but a Mauser wing type.)

The new safety has a precision-made hardened spindle with side-by-side cams which engage the cocking piece and bolt lock. Rocked back to *safe*, the cocking piece is cammed rearward to free the trigger. Simultaneously, the other cam pivots the bolt-lock piece into a notch in the bolt handle. Rocked forward to *fire*, both cams disengage. The cocking piece is eased back onto the sear, the bolt handle is unlocked, and a red dot painted on the bolt sleeve is exposed to warn the rifle is ready to fire.

The trigger is an override type, with a rearward pivoted sear. Except for the lack of an overtravel stop caused by a tie-in with the bolt stop, the

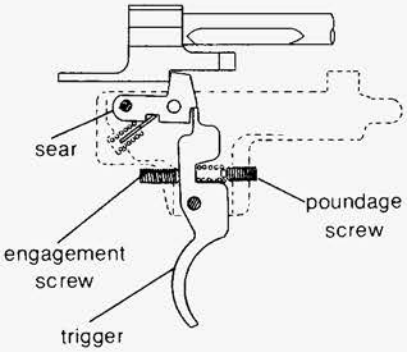

Fire position
Safe position

Weatherby Mark V, operation of safety

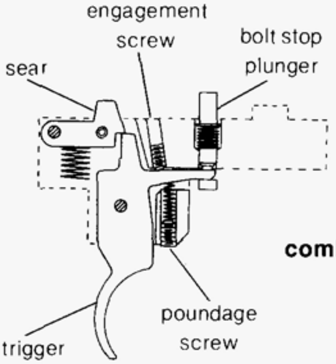
design is good. The sear engages the cocking piece squarely and is actuated upward by a small coil spring (a torsion spring in early versions). A lateral pin limits upward movement (and also served as the cam pin for the pre-'62 safety). Trigger pull is opposed not only by the adjustable poundage spring, but also by the bolt-stop spring.

The cast aluminum trigger housing is attached by a cross-pin and set screw combination. Both poundage and engagement are adjustable, but only with the stock removed.

Sauer Mark V, trigger

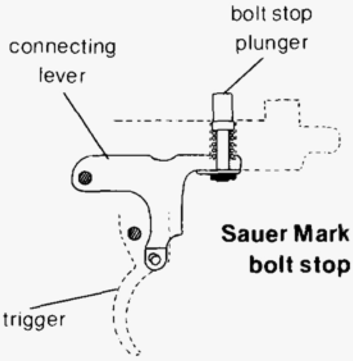

sear
engagement screw
trigger
poundage screw

Howa-made Mark V's have a redesigned unit with several worthwhile improvements. The housing is a milled steel part. The trigger piece is reshaped, with a forward-extending arm to actuate the bolt-stop plunger and form a purchase for the two adjusting screws, which are now mounted vertically to be accessible with the action in the stock, the poundage screw from under the trigger guard and the engagement screw through a slot in the receiver floor. This slot is slightly overlength for this purpose, and thus when Sauer actions are refitted with this new trigger the receivers must be milled to gain access to the engagement adjustment screw. Fred Jennie actually designed this new trigger several years before production was switched to Howa; however, contractual problems had prevented Sauer from retooling for it.



Howa Mark V, combined trigger/bolt stop

Bolt movement is controlled by a plunger projecting from the trigger housing. In the Sauer unit, pulling the trigger fully back rotates a pinned-on connecting lever to force the plunger flush with the receiver bore. The Howa trigger piece itself performs this function, thus eliminating the connector assembly. In both designs, the plunger lacks an override bevel and so trigger pull is also required to insert the bolt—a minor but annoying fault. This

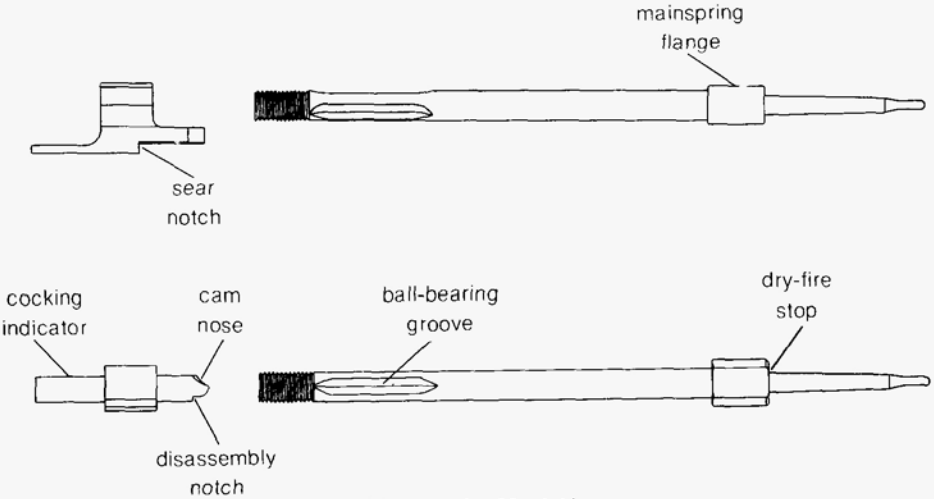


Sauer Mark V, bolt stop

plunger also resists twisting, since the Mark V lacks conventional projecting locking lugs. With the bolt pushed fully forward, a ramp leading to the bolt-body proper prevents interference with bolt closure.

While this bolt stop is not part of the trigger mechanism itself—as with a sear bolt stop, probably the worst arrangement possible—it is not fully independent either. The trigger's performance is limited because the need to actuate the bolt-stop plunger precludes adjusting out overtravel.

A heavy one-piece firing pin threads into the cocking piece and is locked from turning by a steel ball engaging one of three lateral grooves. Besides indexing the firing pin, this ball also limits possible rearward movement from a punctured primer. A flange from the cocking piece extends under the bolt sleeve as a cocking indicator.



Weatherby Mark V, firing pin assembly

In the prototype stages with the removable bolt-sleeve cap, the cocking piece was pinned. But the solid bolt sleeve eliminated access to a cross-pin, and so a ball/flat arrangement was devised. In 1970, the three flutes were substituted to closer control striker fall. While protrusion is controlled by the mainspring flange, and is thus built in, the length of fall is controlled by these threads. For positive ignition, maximum fall is desirable. Since the threads are 5/16 x 24 and are not qualified, a .042 in. variation was possible with the single flat, and ignition was not always as consistent as desirable. It can now be adjusted to within .014 in.

SUMMARY

While it may not measure up to all its claims—few actions could—the Mark V does possess some excellent features. It is big and heavy, but also strong and very safe, easily equal to the most powerful factory cartridges. Few actions can offer the shooter more protection. It does not cam shut smoothly; however, in all fairness, the Mark V is a hunting rather than a target rifle. If worked forward rapidly, the heavy bolt impacts itself onto the cartridge head.

The Japanese-made Mark V retains the machined forgings, and other quality features established in the German rifles. In fact, with the design refinements such as the improved trigger, this third-generation Mark V may turn out to be the best ever offered. The following summarize the strong and weak points of the basic design:

Strong points:

1. Strong breeching and locking.
2. Well designed gas-handling layout.
3. Direct-acting safety.

Weak points:

1. Relatively weak camming layout.
2. Trigger-actuated bolt stop.

WEATHERBY MARK V

Dimensions

OPERATING

Extraction: set-back—.08 in.
leverage—7.5 to 1

Chambering: cam-forward—.08 in.
leverage—10.5 to 1

Bolt rotation—56°

Bolt travel—4.51 in.

Operating forces: bolt lift—10 lb.
press-forward—25 lb.
bolt turndown—7 lb.

Cock-on-opening; .304 in.
mainspring compression
proportioned as follows:
  opening—.251 in.
  closing—.053 in.

IGNITION

Firing pin travel: at impact—.237 in.
  dry-fired—.304 in.

Lock time—3.6 ms.

Impact velocity—12.4 ft./sec.
  energy—78.9 in.-oz.
  impulse—1.06 oz.-sec.

Striker/firing pin hole diameters—.077 in./.082 in.

RECEIVER

Overall length—9.00 in.

Length of loading/ejection port—3.25 in.

Ring diameter—1.335 in.

Barrel/receiver threads: designation—1$\frac{1}{16}$-16
  engagement—.53 in. (8.5 threads)

Recoil lug: width—1.11 in.
  height—.40 in.
  thickness—.380 in.
  bearing area—.44 sq. in.
  clearance from magazine—.68 in.

Guard screws: front—¼x28
  rear—¼x28

Scope mounting—6x48 screws

BOLT

Lug shear area—.342 sq. in.

Lug bearing area—.108 sq. in.

Bolt diameter—.839 in.

Lug recess diameter—.710 in.

Lug diameter—.839 in.

Bolt face: type—counterbored
depth—.120 in.

MAGAZINE

Length—3.74 in.

Depth: front—1.91 in.
rear—2.13 in.

Capacity: .240 Weatherby Magnum (.470 in. head)—5
.30-06 Springfield (.473 in. head)—4
.300 Weatherby Magnum (.532 in. head)—3
.378 Weatherby Magnum (.603 in. head)—2

WEIGHT

Receiver group—20.8 oz.

Bolt group—18.1 oz.

Magazine/floorplate group—11.6 oz.

Total action weight—50.5 oz.

OPERATION

By the time we get to this Weatherby rifle, a number of detail differences have developed from the operating sequence described at the beginning of this book for the Mauser M98 action. Thus an operational description is repeated here, based on the Mark V, and again starting with a fired cartridge.

Bolt lift begins the process of mainspring compression. As the bolt handle is raised, the cocking notch acts against the non-rotating cocking piece, driving the firing pin rearward. By the completion of bolt lift, the cocking piece nose has been moved over into a small holding notch on the bolt rim where it is locked by mainspring compression to index the bolt group. It remains in this partially cocked position until fully compressed later during bolt turndown.

The first 30° or so of bolt lift also unlocks the nine bolt-head lugs from their seats in the receiver ring. Once the locking faces clear, the bolt is free to begin moving back. As rotation continues, a hardened bevel on the bolt handle contacts the bridge to force the bolt a small distance rearward for primary extraction of the fired case.

When the bolt-stop plunger and the bolt handle collar stop bolt lift, the action of the cocking cams, combined with the rearward displacement from the extraction cams, has reset the trigger.

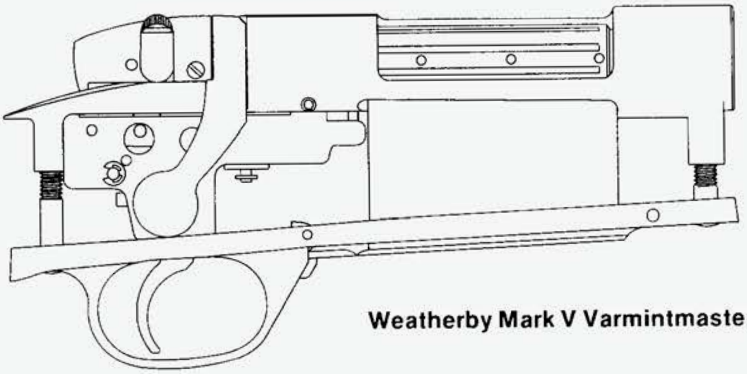
As the bolt is drawn back, its piston-like fit in the receiver provides guiding support. The bolt-stop plunger, rather than a conventional locking lug setup, prevents twisting or binding. Since the plunger gives even and continuous support over the entire bolt movement, a smooth non-binding action results. The extractor claw drags the spent case clear of the receiver ring, where the spring-powered ejector then propels it out the loading port to complete the extraction/ejection process. The bolt is stopped by the bolt-stop plunger just clear of the magazine, allowing another cartridge to rise up into feeding position.

As the bolt is worked forward to begin the closing cycle, it strips the cartridge from the magazine and drives it into the chamber. Done rapidly, momentum of the bolt forces the bolt counterbore onto the cartridge head, engaging the extractor. Since the extractor does not engage the cartridge head during the feeding process, as in the Mauser M98, there is a less positive control of the cartridge. Once fully forward, the bolt is clear for turndown. The locking lugs are positioned into camming alignment with their seats and the bolt-stop plunger is adjacent its escape ramp.

As the bolt is first turned down, and cammed forward by the locking lugs, the sear picks up the cocking piece, lifting it from its holding notch to unlock the bolt sleeve. Further camming advances the bolt to battery position, chambering the cartridge, depressing the bolt-stop and ejector plungers, and completing mainspring compression. When the bolt handle bottoms in its receiver-tang notch the action is aligned for firing, with the locking lugs in full engagement and the deep portion of the cocking notch in line ahead of the cocking piece.

Pulling the trigger removes support from the sear, allowing the mainspring to snap the firing pin into the primer. Contact of the striker point and primer stops the firing pin well short of full protrusion, preventing the mainspring flange from impacting into the bolt head. Ignition expands the cartridge body and neck out against the chamber walls. Rearward movement is blocked by the bolt, this in turn driving the locking lugs into their seats. When chamber pressure subsides, the cartridge brass springs back just enough to release tension on the bolt lugs and permit unlocking the action to begin another cycle.

WEATHERBY MARK V VARMINTMASTER



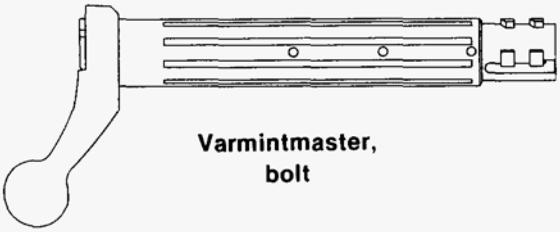
Weatherby Mark V Varmintmaster

The Mark V was designed from the beginning for long magnum cartridges, and is thus somewhat oversize for standard big-game cartridges like the .30-06, not to mention most varmint cartridges.

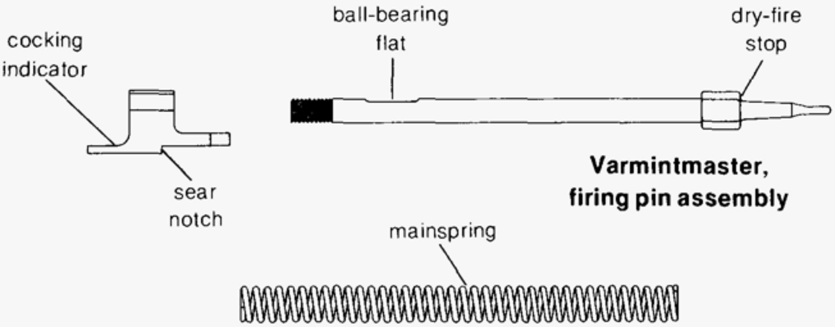
In order to enter this latter field, Weatherby began work in 1963 on the Varmintmaster, a miniature version of the original Mark V. Unlike other Weatherby firearms, it was not designed at South Gate. It came along during the five-year period when Fred Jennie had left Weatherby to work at Norris Industries, and all design work was handled in West Germany by J. P. Sauer & Sohn.

Except for the trigger assembly, dimensions of the major Varmintmaster parts are basically scaled down about 20%, resulting in an overall weight reduction of 40%. In fact, whereas the Mark V is one of the largest and heaviest of all bolt actions, the Varmintmaster is one of the smallest and lightest, being roughly comparable to the tiny Sako Vixen.

Since it was primarily a process of scaling down, there are really no significant design changes to examine. The same locking system is used, except with only six lugs. Unfortunately, the one significant weakness of the Mark V, the lack of strong closing cams, was also carried over, even less appropriate in a varmint rifle than in the big-game Mark V.



Varmintmaster, bolt



Varmintmaster, firing pin assembly

The Varmintmaster was introduced in 1964 in conjunction with the .224 Weatherby Magnum, a miniature belted-head cartridge. Design of this cartridge was entirely new, and in retrospect, probably more significant than the Varmintmaster action itself, although neither has yet generated the kind of interest that some previous Weatherby developments had.

This was actually the second attempt at a Weatherby varmint cartridge. In the mid-1950s, Weatherby introduced a blown-out .220 Winchester Swift termed the .220 Weatherby Rocket. It was rather short-lived, since one thing the Swift never suffered from was a lack of powder capacity.

The .224 Weatherby, on the other hand, was the most original U.S. cartridge since Remington's .222. It introduced a new head size (.429 in.) intermediate between the .222 family (.376 in.) and the .30-06 family (.473 in.). While its belted-head may be of little significance, many believe the geometry of its powder cavity offers interesting possibilities in the accuracy field.

WEATHERBY MARK V VARMINTMASTER

Dimensions

OPERATING

Extraction: set-back—.07 in.
leverage—6.5 to 1

Chambering: cam-forward—.05 in.
leverage—17.5 to 1

Bolt rotation—57°

Bolt travel—3.28 in.

Operating forces: bolt lift—12.5 lb.
press-forward—13 lb.
bolt turndown—5 lb.

Cock-on-opening; .296 in.
mainspring compression
proportioned as follows:
opening—.257 in.
closing—.039 in.

IGNITION

Firing pin travel: at impact—.239 in.
dry-fired—.296 in.

Lock time—2.9 ms.

Impact velocity—15.2 ft./sec.
energy—70.7 in.-oz.
impulse—.78 oz.-sec.

Striker/firing pin hole diameters—.078 in./.082 in.

RECEIVER

Overall length—7.60 in.

Length of loading/ejection port—2.44 in.

Ring diameter—1.085 in.

Barrel/receiver threads: designation—⅞-18 UNS
engagement—.50 in. (9 threads)

Recoil lug: width—.87 in.
height—.49 in.
thickness—.375 in.
bearing area—.42 sq. in.
clearance from magazine—.74 in.

Guard screws: front—¼x28
rear—¼x28

Scope mounting—6x48 screws

BOLT

Lug shear area—.188 sq. in.

Lug bearing area—.074 sq. in.

Bolt diameter—.705 in.

Lug recess diameter—.585 in.

Lug diameter—.705 in.

Bolt face: type—counterbored
depth—.121 in.

MAGAZINE

Length—2.52 in.

Depth: front—1.89 in.
rear—2.03 in.

Capacity: .224 Weatherby Magnum—4
.22/250 Remington—3

WEIGHT

Receiver group—13.2 oz.

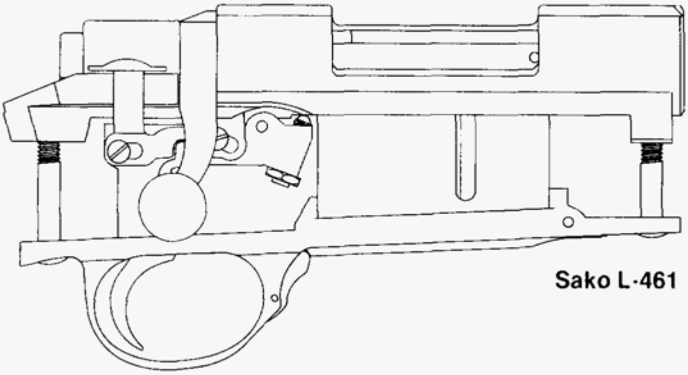
Bolt group—10.8 oz.

Magazine/floorplate group—7.3 oz.

Total action weight—31.3 oz.

11

Sako L-461 Vixen



Sako L-461

The Vixen is the smallest of three turnbolt actions made by Oy Sako Ab, Riihimäki, Finland, and distributed in this country by Garcia Sporting Arms Corporation (formerly Firearms International Corporation, better known as simply F.I.). Each of the three—the Vixen, Forester, and Finnbear—is tailored in size and strength for a specific range of cartridges, thus forming a full line of extremely trim, efficient, and attractive actions.

Design work on the original version of this action was begun during World War II by Niilo Talvenheimo. The first prototype was ready in 1942 and designated the Sako L-42. After four major revisions, the L-46 was adopted for manufacture in 1946 and introduced throughout Europe. The rifle was subsequently distributed here beginning in 1948 and chambered for .22 Hornet and .218 Bee. Later, the longer .222 Remington and .222 Remington Magnum cartridges were added. These tended to crowd the action a little and in 1961 a lengthened out version designated the L-461 was developed by Eino Mäckinen.

Besides being opened up, the L-461 went to a top loading double-column magazine, plunger trigger with a sliding safety, and a threaded firing pin. These replaced a detachable single-column magazine, Winchester Model 70 type trigger, direct-acting safety fitted into a square-shaped bolt sleeve, and lugged firing pin in the L-46.

Sako uses a unique cumulative type of chronological designation. L-46 production started in 1946. Its revised successor was begun in 1961, thus adding the last digit for L-461. Forester production began in 1957 and so the designation L-57. It was modified in 1959 to become the L-579. Finnbear production started in 1961 to give the L-61 designation.

This system does not extend to four digits, and there have since been Model 72 and Model 74 versions of the Vixen. This rifle was previously called the "Sako Short-Action Mauser" and then the "Sako Sporter." The animal name was substituted in 1959 to give a more Finnish flavor, since Sako properly pronounced (Sock-o) sounds very Japanese.

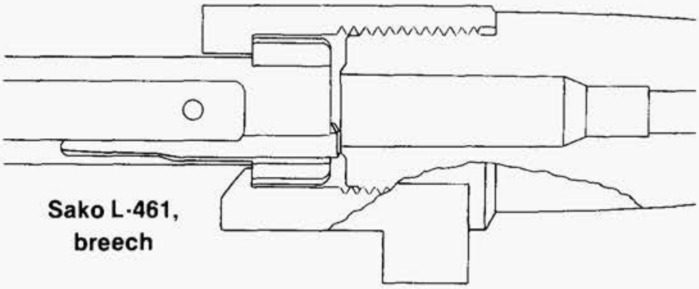
The breech is one of this rifle's weak points. Unlike most other modern designs, the Sako bolt-face counterbore depth fails to match the protrusion of the case head from the barrel, thus leaving much of it unshrouded.

With rimless cartridges and turning-bolt actions, cartridges cannot be seated flush with the chamber mouth (as in some single-shot type actions, where breech closure is, using an expression coined by Major George Nonte, "like nailing a board over a rat hole"). The head must protrude enough to expose the rim and at least part of the cannelure, depending on the particular extractor form. With the sharp knife-like Mauser claw, only slightly more than 3/32 in. exposure is necessary. With the recessed Remington C-hook extractor, about 5/32 in. is needed. Most modern configurations fall within these, with about 1/8 in. as typical.

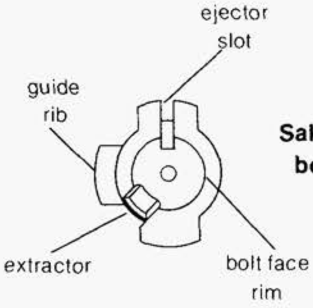
The idea of the counterbored bolt is to cover over this exposed head, shrouding the brass with a steel ring to oppose and limit any possible expansion. Accordingly, post-war American design practice closely matches bolt-face counterbore depth to cartridge-head protrusion, leaving only a minimal gap between the bolt and barrel, often as little as .010 in.

The Vixen pattern does seat the cartridge deeply into the barrel (certainly a plus feature) and the head protrudes only .107 in. This is measured from a .025 in. high lip encircling the chamber mouth. Because of a thick extractor head, a clearance slot was milled into the L-46 barrel. To simplify production, this slot was extended all the way around in the L-461, making for a symmetrical lathe operation. On closing, the extractor cams out slightly over this lip to avoid interference.

The bolt face counterbore is only .057 in. deep, and so despite the good protrusion figure, a .050 in. gap is left. What bolt-rim walls do exist are weakened by ejector and extractor slots. Thus, as with the Springfield rifle, while the design has a lot of service behind it, it nevertheless lacks the extra margin of protection of other modern designs. Modernization of the Vixen, to, among other things, employ a plunger ejector and a deeper bolt-face counterbore, was suggested by F.I. several years ago. Changes of this nature, however, occur very slowly in Finland.



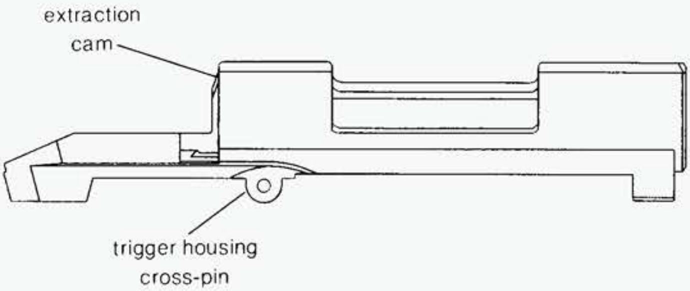
Sako L-461, breech

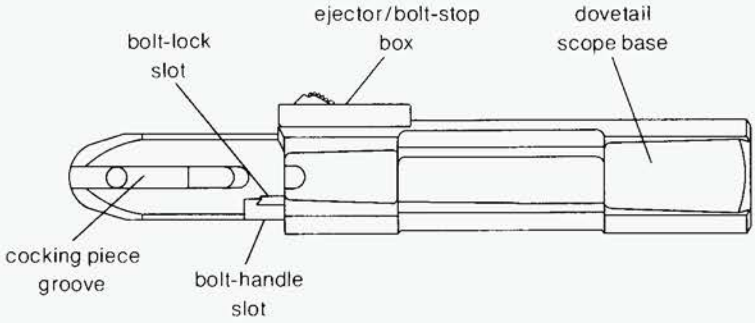


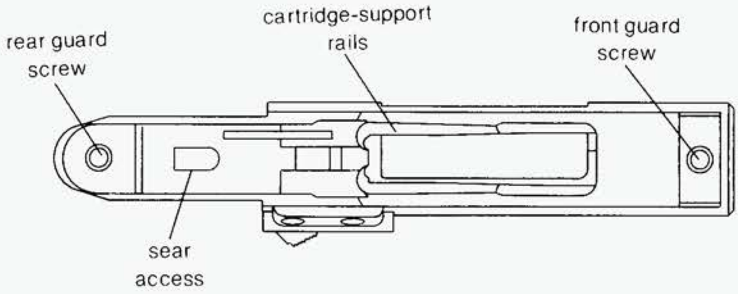
Sako L-461, bolt face

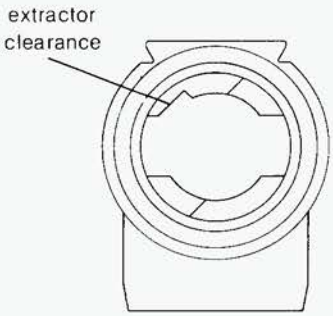
The miniature Vixen receiver is machined from a length of chrome-moly barstock. Two guard screws are used, located under the recoil lug and rear tang. On top, integrally machined dovetails, which are initially cold-drawn into the barstock blanks, form the base for an ultra-rigid scope mounting system.

The recoil lug is small, yet about equal to that of the Mauser M98, and so more than adequate for the .222 cartridge family. A .81 sq. in. pad behind

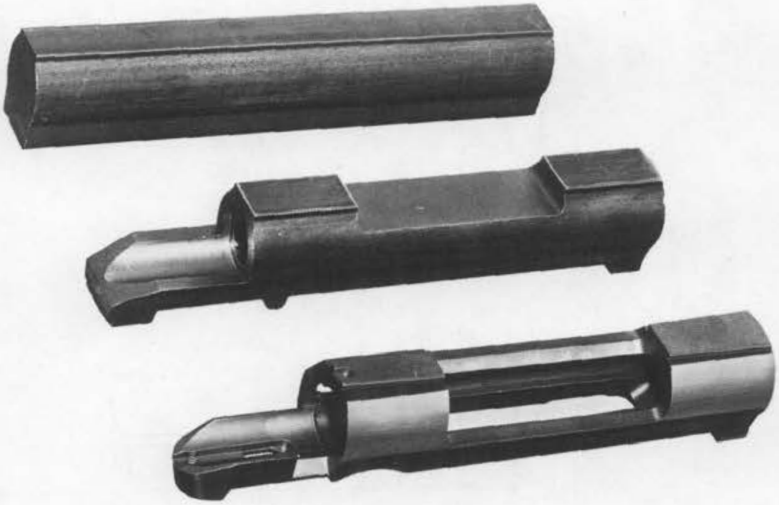

extraction cam
trigger housing cross-pin


ejector/bolt-stop box
dovetail scope base
bolt-lock slot
cocking piece groove
bolt-handle slot


cartridge-support rails
rear guard screw
front guard screw
sear access


extractor clearance

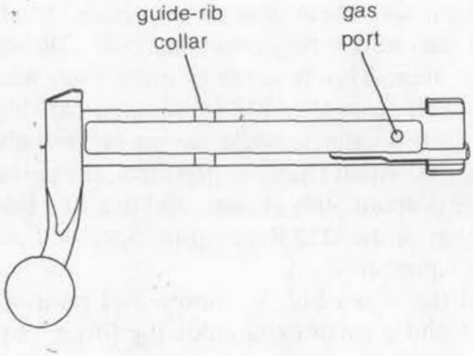
Sako L-461 receiver, front view

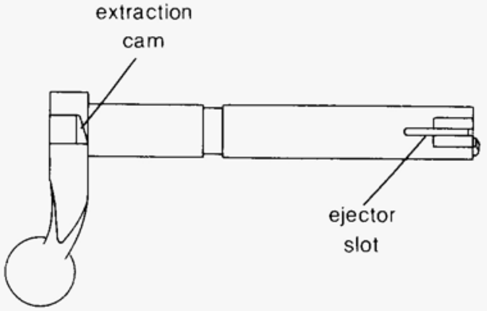


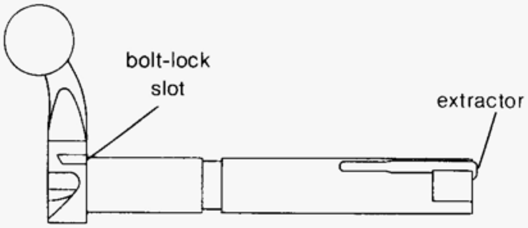
Sako L-61
Receiver in process

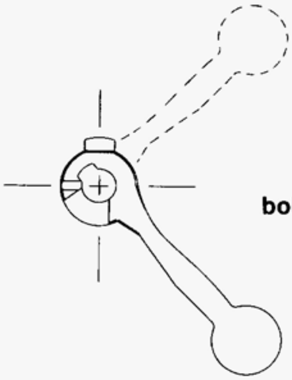
the recoil lug beds onto the stock, about all the surface area possible in such a small receiver. A *benchrest* version of the Vixen is also available, which eliminates the magazine to create a solid bottom for added rigidity and bedding surface.

The bolt is machined from a one-piece chrome-moly forging. Its diameter is about 20% smaller than in most full-sized actions. An enlarged rear hub provides extra metal for the cocking cam and for bolt-sleeve retention. At the front are two locking lugs. The right lug is solid, except for a small wedge milled from its base for the extractor, while the left lug is cut in two by the ejector slot.





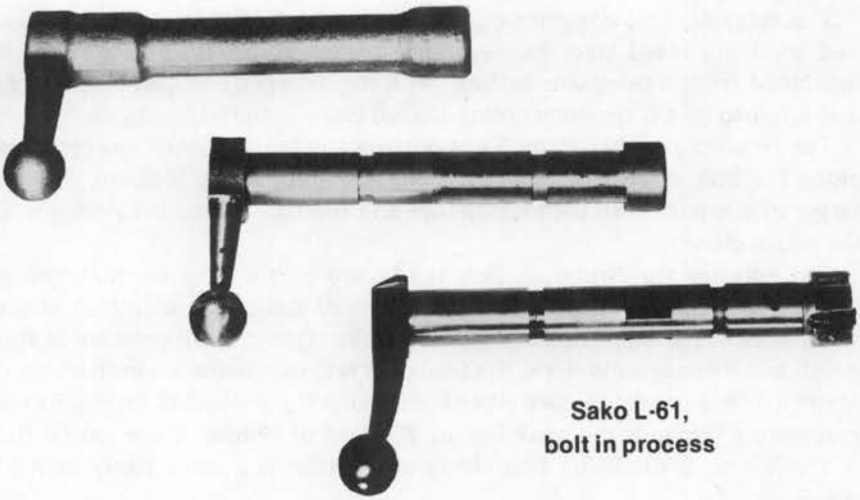




Sako L-461, bolt-handle profile

In keeping with the overall size of the action, the lugs are small, their engagement in the receiver ring providing only .236 sq. in. shear and .035 sq. in. bearing area. This is actually more than adequate, however, to contain back thrust from the .222 Remington cartridge head. Most other action designs in this caliber, while having larger bolts, are used also for larger cartridges. At equal chamber pressures, the potential back thrust of a .30–06 cartridge is about 50% greater, and that of a belted-head cartridge is about double that of the .222 Remington. Specific figures and calculations are given in the Appendix.

Operation of the Vixen bolt is smooth and positive, due in part to the compact stroke and a small extra guide lug formed by the top of the bolt

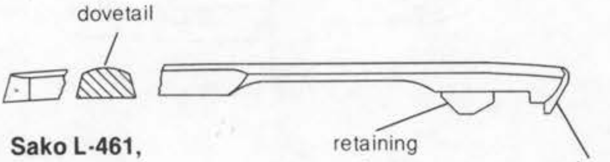


Sako L-61, bolt in process

handle, but mainly due to the close-tolerance, high finish precision of the working parts. The only really special bolt-support device is a collar-mounted guide rib in the right raceway.

This guide rib originally only filled in the right raceway to minimize lateral play. In 1970, the Vixen bolt was slotted for a stop-wedge under the guide rib to stop rotation at full lift, and thus now also support the bolt from twisting, an idea used more than 50 years previous in the Newton rifle. About a year later this was further refined to a double-wedge which controls rotation in both directions to prevent accidently positioning the rib behind the left locking lug and deactivating the bolt stop.

The Vixen extractor is an early Mauser type (U.S. Patent 431,670 issued July 8, 1890). It occupies a slot over the right locking lug and is secured at the rear by a dovetail. Forward of this, it can spring outward, acting like a cantilever and held in flush by only its sturdy but resilient construction. A small lug under the head anchors the extractor lengthwise. The design requires precision machined parts, but makes possible a simple and efficient arrangement, eliminating the need for either a separate retaining collar or actuating spring.



Sako L-461, extractor

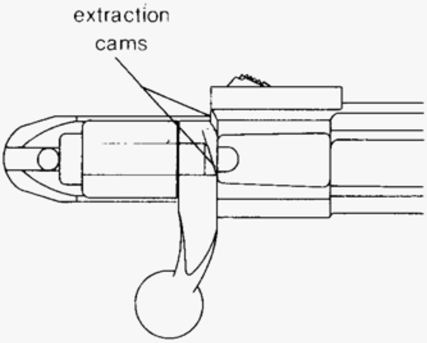
The magazine is a staggered-column type, with folded steel cartridge box and solid machined steel follower. The trigger guard/floorplate frame is machined from a one-piece casting, with the floorplate hinged to the front and retained by a convenient spring-loaded catch in the trigger bow.

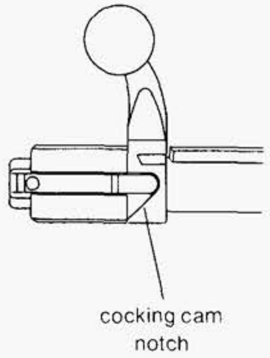
The receiver ring has a small gas port on the left side. Any gas escaping along the bolt exterior is blocked by its rear hub, which is about .030 in. larger in diameter than the locking lugs and recesses behind the bridge with the action closed.

Gas entering the firing pin hole is blocked partially by the mainspring flange, creating in turn, however, a potential gas-piston effect. A single small port in the bolt head and guide rib can release some pressure at this point, but if enough develops, the firing pin is driven rearward until stopped about 1 1/8 in. past full-cock when the mainspring goes solid. Normally the mainspring flange is the weak link in this kind of system, if one exists. But in the Vixen, a single-lug bolt sleeve attachment is a more likely item of concern.

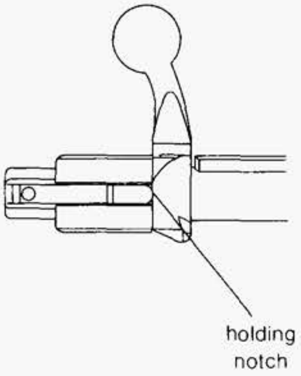
The cams are a strong feature in the Vixen. They are not only physically well designed—with relatively massive, well-shaped, and smoothly finished working surfaces—but are also proportioned to give very efficient combinations of leverage and displacement, a unique advantage gained by designing a special action for small cartridges. Powerful mechanical advantages, running almost double most other Mauser-type actions, allow handling the little .222 Remington cartridges with unusual ease.

The extraction cam surfaces are large and carefully shaped, distributing contact forces and eliminating danger of the gouging often seen on more sharp-edged configurations. The cocking cams are equally superior, with a gently sloping cam notch in the enlarged-diameter bolt hub acting against a rounded nose on the cocking piece. The rear rim is more than double the thickness usually found, thus giving an extra large contact area to help guarantee long, trouble-free life of the cocking system.





Uncocked

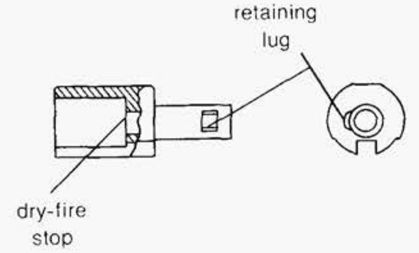


Cocked

On closing, the locking lugs cam forward .10 in. at a 17 to 1 leverage to chamber the cartridge and engage the extractor. They also accomplish the final .004 in., or 1.4% of mainspring compression.

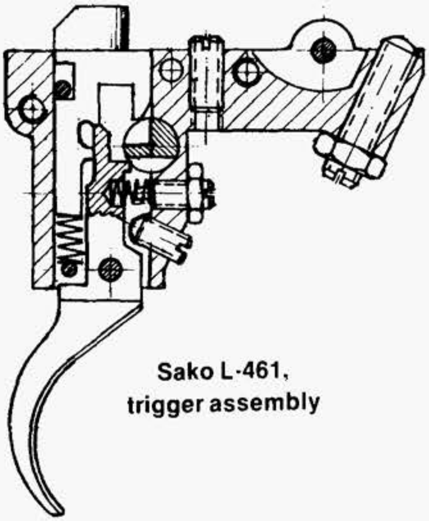
The process of mainspring compression is seldom 100% efficient. For one thing, the holding notch represents lost work. Further, cock-on-opening requires the bolt to begin turning before the sear picks up, and if this sequence is not controlled carefully, the cocking piece can drop partially into the cocking notch during initial closing, thus losing mainspring compression. This occurs in the Vixen, as is obvious by comparing the closing cam-forward figure (.10 in.) with the very small *net* mainspring compression during closing (.004 in.). So the net figures given in this book may not always precisely define the process of mainspring compression, which is not entirely smooth and continuous. In most actions, however, the cocking piece picks up sooner during bolt turndown and the net figures give a more accurate picture.

Attachment of the bolt sleeve to the rear of the bolt uses another early Mauser principle, with a single small lug in place of the usual threads. U.S. Patent 440,955 issued Nov. 18, 1890, to Paul Mauser sets forth this lug system and the buttress thread attachment which he ultimately adopted. Interestingly enough, the lug system was the favored embodiment in the patent disclosure. While obviously not as strong as the threaded-on type, it does simplify disassembly. The bolt can be stripped by simply rotating the bolt sleeve a fraction of a turn to align this lug with an escape slot in the bolt rim.



Sako L-461, bolt sleeve

The trigger is a single-stage override type, with the sear sliding vertically over the trigger piece. The sliding contact between the sear and trigger housing creates more binding potential than the more common pivoted types, requiring extra care to keep the mechanism clean.



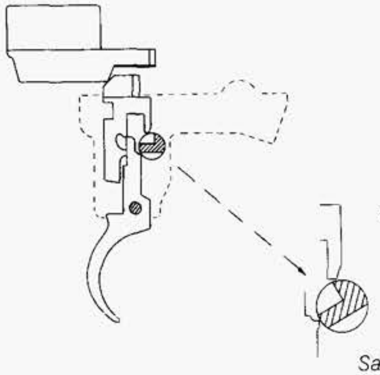
Sako L-461, trigger assembly

The Vixen safety does not fit neatly into any of the usual categories. It functions to block trigger movement, yet can also directly block the sear. A large precision-machined spindle is controlled by a stamped assembly comprising a thumbpiece and bolt-lock blade at opposite ends, and guiding on two screws in the trigger housing. Elongated holes allow movement back and forth to two positions established by a spring-loaded detent ball. At the rear (safe) position, the spindle is rotated to block both the trigger and sear, and the bolt-lock blade enters a slot under the bolt handle.

This Sako safety has the operating ease of the simple trigger-block type, requiring no camming or leverage, yet it is clearly functionally superior. Even should the fine trigger/sear engagement (about .010 in.) fail, the firing pin remains blocked.

The bolt stop pivots in a box on the left wall of the bridge. It is a sturdy lug machined integral with the ejector blade and urged inward by a small torsion spring to block passage of the left locking lug. A serrated release button projects from the box, creating a trim unit and one which can be operated with the same hand that holds the rifle, leaving the other free to work the bolt.

The one-piece firing pin threads into the cocking piece and is locked by a small set screw registering with one of four lengthwise slots in the threads.

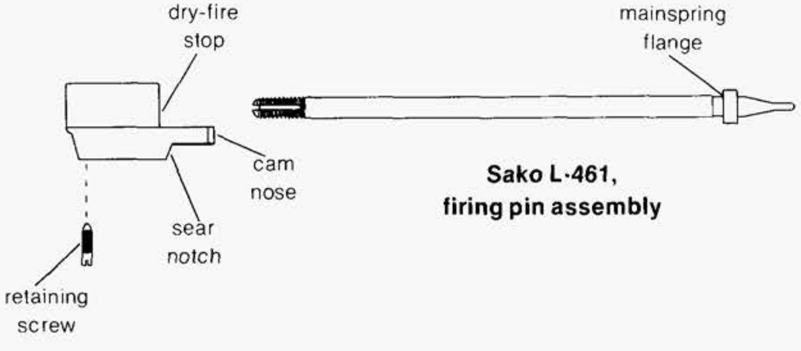


Sako L-461, operation of safety

Dry firing is controlled by the cocking piece, and thus these threads control both firing pin protrusion and length of fall. They have a 1mm pitch, so that a quarter-turn changes protrusion by about .010 in. F.I. recommends the limits of .067 to .083 in.

Since protrusion is readily adjustable in the Vixen, it might be interesting to examine its effect. With a .069 in. protrusion, mainspring pre-load is 21.6 lb. (final compression is 18.0 lb. in all cases, since the striker point controls this). This setup gives a .210 in. striker fall and a 66.5 in.-oz. striker blow.

If the firing pin is unthreaded a half-turn, giving .089 in. protrusion, what results? A common assumption is a stronger indentation on the primer, or even a dangerously severe percussion effect since the recommended limits have been exceeded. The opposite actually occurs, since both initial pre-load and striker fall decrease, and a *softened* striker blow results. Mainspring pre-load is now only 21.3 lb., and more important, travel is .020 in. less, resulting in an impact of only 59.7 in.-oz.



Sako L-461, firing pin assembly

If the firing pin were instead turned inward to reduce protrusion to .049 in., will indentation be insufficient for reliable ignition? Again, the opposite is true. With a 21.9 lb. pre-load and .020 in. more fall for the striker to pick up velocity, a 73.5 in.-oz. impact results. The entire subject of protrusion, striker energy, and pierced primers is considered in detail in the Appendix.

SUMMARY

The Vixen is a popular action, being used not only in the Sako-made rifles, but also in several other high-quality arms, including the Browning, the H&R "Ultra" line, and the former Winslow line. This popularity is well founded. It is trim, attractive, and efficient. Machining and finish are perhaps the finest of any commercial bolt action. Functioning is smooth and reliable.

From a pure design standpoint, however, it is in some respects only passable. It lacks a strong breech and gas-handling system. The trigger has a limited potential. And the receiver lacks the degree of bedding and rigidity usually necessary to attain maximum performance from a good barrel.

The basic action has never really been updated since it was designed during World War II. It is too successful. By streamlining the styling, it has attained a popularity that makes Sako's main problem one of keeping up with demand. The following summarizes the action's strong and weak points:

Strong points:

1. Smooth and positive operation.
2. Scarcity of stamped parts.
3. Positive and controlled ejector.

Weak point:

1. Incomplete cartridge-head encirclement.

SAKO L-461 VIXEN

Dimensions

OPERATING

Extraction: set-back—.06 in.
leverage—18 to 1

Chambering: cam-forward—.10 in.
leverage—17 to 1

Bolt rotation—91°

Bolt travel—3.00 in.

Operating forces: bolt lift—5 lb.
bolt turndown—5 lb.

Cock-on-opening: .279 in.
mainspring compression
proportioned as follows:
opening—.275 in.
closing—.004 in.

IGNITION

Firing pin travel: at impact—.210 in.
dry-fired—.279 in.

Lock time—2.9 ms.

Impact velocity—13.4 ft./sec.
energy—66.5 in.-oz.
impulse—.83 oz.-sec.

Striker/firing pin hole diameters—.068 in./.073 in.

RECEIVER

Overall length—7.08 in.

Length of loading/ejection port—2.14 in.

Ring diameter—1.185 in.

Barrel/receiver threads: designation—.864-16
engagement—.59 in. (9.5 threads)

Recoil lug: width—.98 in.
height—.28 in.
thickness—.438 in.
bearing area—.27 sq. in.
clearance from magazine—.83 in.

Guard screws (metric): front—M6x1
rear—M6x1

Scope mounting—integral dovetails

BOLT

Lug shear area—.236 sq. in.

Lug bearing area—.035 sq. in.

Bolt diameter—.554 in.

Lug diameter—.765 in.

Rear hub diameter—.797 in.

Bolt face: type—counterbored
depth—.057 in.

MAGAZINE

Length—2.34 in.

Depth: front—1.94 in.
rear—2.03 in.

Capacity—6

WEIGHT

Receiver group—17.5 oz.

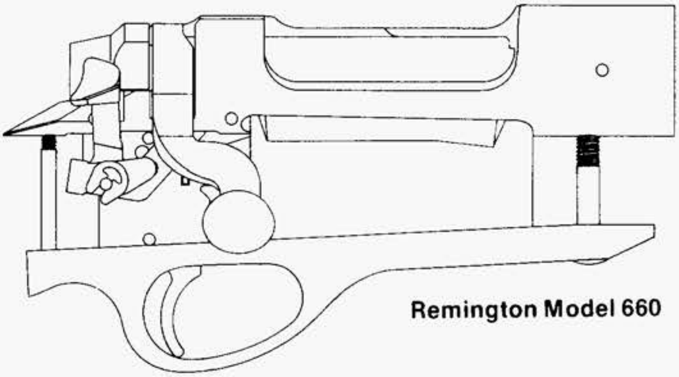
Bolt group—8.9 oz.

Magazine/floorplate group—6.3 oz.

Total action weight—32.7 oz.

12

Remington Models 600, 660, and Mohawk-600



Remington Model 660

In the early 1960s, Remington developed a shortened version of the Model 700 action for use in the XP-100 pistol. Soon after, the same basic pattern was adopted for a new carbine-sized rifle, designated the Model 600 and introduced in January, 1964.

The Model 600 combined the length and weight of a carbine with the strength and reliability of a standard-size bolt action, suitable for modern short magnum cartridges. It also expanded Remington's centerfire line by putting them in a lower price range than possible with their first-line Model 700 series.

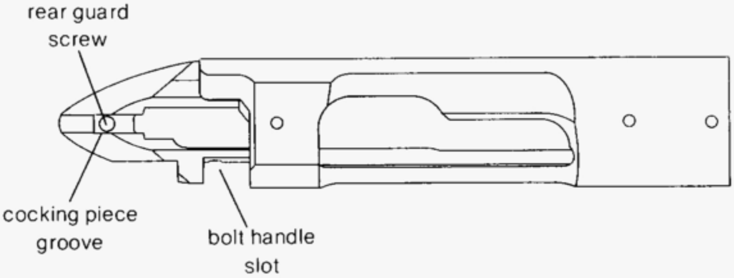
While outwardly modified, the Model 600 still retained most of the design patterns of the Model 700, and, in fact, was made on the same machining stations. The receiver-ring area—which includes such critical items as the locking lugs and seats, breech, barrel threading, and extractor and ejector—is virtually identical. All the significant changes are at the rear. Basic features already covered under the Model 700 will not be repeated here, and we will concentrate only on the differences between the two series. Thus, besides being brief, this chapter may seem negative, since many of these changes were economy measures to lower the price bracket.

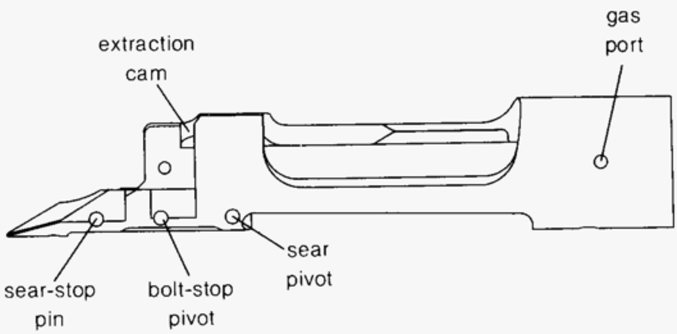
The Model 600 underwent the same type changes in 1968 as the Model 700, and also a name change, redesignated the Model 660. In 1971 it was again renamed, this time the Mohawk-600. It is no longer marketed exclusively through traditional Remington channels, but now also through discount merchandisers.

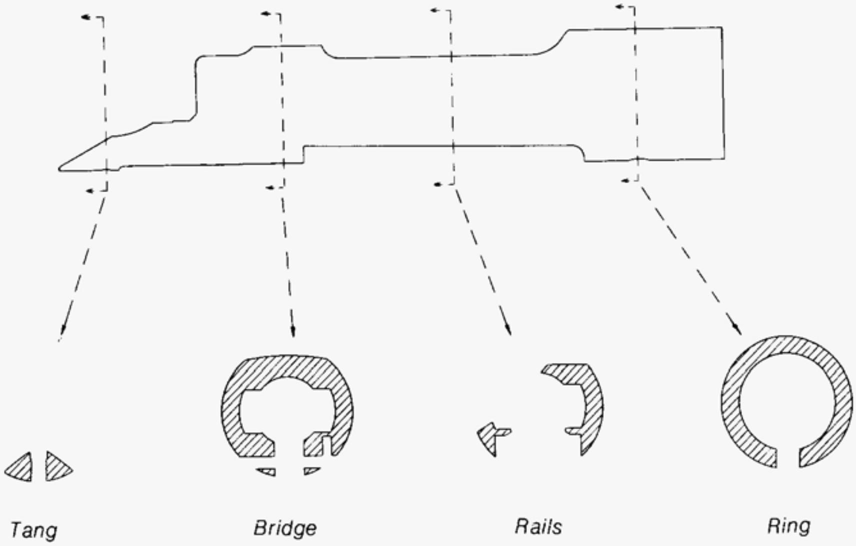
The receiver is cylindrical, machined from chrome-moly barstock. The ring area, establishing the action's strength, is basically unchanged from the Model 700. Overall receiver length is shorter, however (the 600, 700 short, and 700 standard run approximately 7, 7.85, and 8.7 in. respectively). Rather than being a simple *chopped-down* version of the 700 receiver (which wouldn't work, since its loading port was a practical minimum length), the 600 is completely reconfigured at the rear. It is almost 7/8 in. shorter overall than the Model 700, but its loading port is 1/4 in. longer. This trick, which permits handling some belted magnums, required eliminating much of the bridge and rear tang. The bridge ended up so short as to allow only room for a single scope-mount hole.

The trigger is immediately behind the magazine, leaving little metal under the bridge. The rear tang also lacks size, tapering almost to a point. Receiver rigidity and bedding potential are thus weakened. Different size guard screws are used, 1/4 x 28 at the front and 8 x 36 at the rear. The recoil lug is a bracket as in the Model 700, except with tapered sides and projecting, in all but early versions, slightly above the receiver ring for the purpose of providing a recoil anchor for a front scope base.

The bolt is dimensioned and fabricated like the Model 700's, except for its overall length and a handle which is dog-leg shaped to place the knob up next to the forward-mounted trigger and flattened underneath to hug the

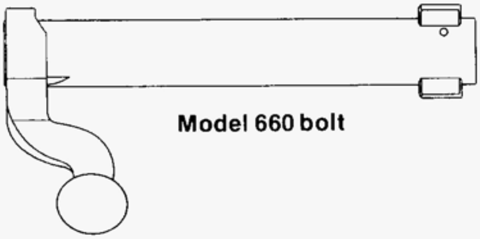



extraction cam
gas port
sear pivot
sear-stop pin
bolt-stop pivot

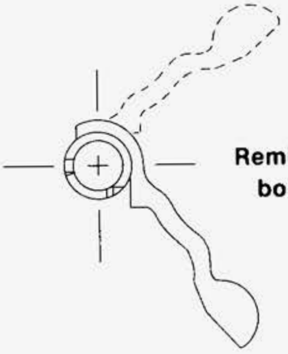

Tang
Bridge
Rails
Ring

Remington Model 660,
receiver sections

stock and thus better adopt to a saddle scabbard. In the Summary of this chapter, the lug bearing area given is less than that listed for the Model 700 bolt in Chapter 9. This does not, however, reflect a design difference, but simply tolerance variations in the samples involved. The lugs on our sample Model 660 were overchamfered, and it had slightly less bolt rotation than normal. Since much of the same tooling is used to make both, undoubtedly samples could easily be found with the situation reversed.



Model 660 bolt



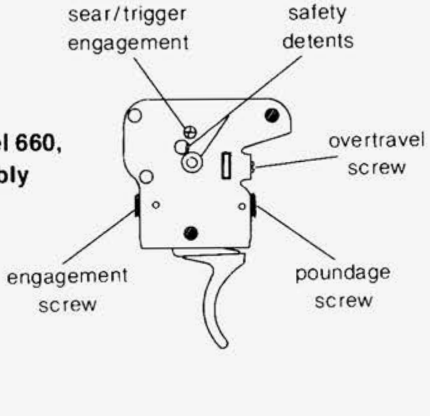
Remington Model 660, bolt-handle profile

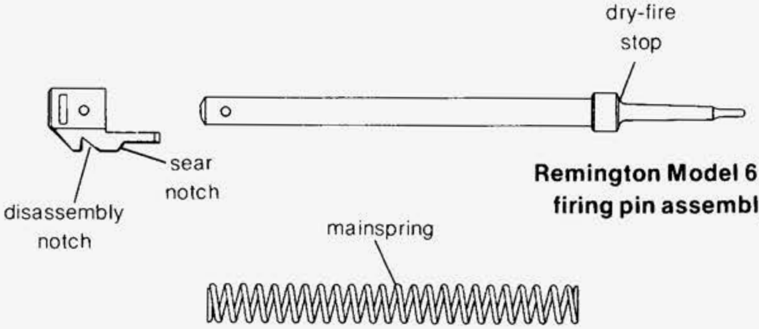
The trigger guard/floorplate assembly is a one-piece molded-plastic unit, without a detachable floorplate. A stiffening ridge along the center and extending under the magazine protrudes below the stock, making it difficult to lay the rifle on a table or bench without it falling on its side, a very unhandy feature.

The trigger is like the Model 700 except with the folded sheet metal housing of the 721/722. The stamping supports the adjusting screws, which in turn anchor it together. The overtravel pin threads into two tabs bent at right angles, while the poundage and engagement screws are of large diameter to thread directly into opposing walls of the housing. Thus the screws act as cross-braces to give the otherwise flimsy sheet-metal housing rigidity to properly support the working parts. The concept is clever, but in practice does not provide the precision and performance of the sturdier block-type construction in the Model 700 trigger.

The bolt stop is a pivoted blade, like that in the Model 700 except without convenient means of operation. There wasn't room for the Model 700 release linkage, and so rather than design a new layout, it was simply

Remington Model 660, trigger assembly





Remington Model 660, firing pin assembly

omitted. A small screwdriver or punch must be worked into the left raceway for bolt removal, a most inconvenient arrangement in a rifle used and cleaned often.

SUMMARY

Because the Model 600 series lacks much of the refinement of the Model 700, it is best suited for special purposes. The plastic trim, crude bolt stop, and dog-leg handle rule against putting together a top-flight custom rifle of conventional form. Where unusual compactness and light weight, combined with extreme strength, is the prime object, however, it is hard to beat. The following summarizes the action's strong and weak points:

Strong points:

1. Strong breeching and locking.
2. Positive and convenient safety.
3. Fully adjustable trigger.
4. Light weight.

Weak points:

1. Unattractive and bulky plastic trim.
2. Inconvenient bolt stop.
3. Lack of detachable floorplate.

REMINGTON MODELS 600, 660, AND MOHAWK-600

Dimensions

OPERATING

Extraction: set-back—.08 in.
leverage—8 to 1

Chambering: cam-forward—.12 in.
leverage—7.5 to 1

Bolt rotation—86°

Bolt travel—3.86 in.

Operating forces: bolt lift—8.5 lb.
bolt turndown—9 lb.

Cock-on-opening; .279 in.
mainspring compression
proportioned as follows:
opening—.226 in.
closing—.053 in.

IGNITION

Firing pin travel: at impact—.228 in.
dry-fired—.279 in.

Lock time—2.8 ms.

Impact velocity—14.9 ft./sec.
energy—77.3 in.-oz.
impulse—.86 oz.-sec.

Striker/firing pin hole diameters—.075 in./.078 in.

RECEIVER

Overall length—6.97 in. (7.15 in. with recoil bracket)

Length of loading/ejection port—2.62 in.

Ring diameter—1.355 in.

Barrel/receiver threads: designation—1$\frac{1}{16}$-16
engagement—.69 in. (11 threads)

Recoil lug: thickness—.185 in.
bearing area—.49 sq. in.
clearance from magazine—1.47 in.

Guard screws: front—¼x28
rear—8x36

Scope mounting—6x48 screws

BOLT

Lug shear area—.424 sq. in.

Lug bearing area—.080 sq. in.

Bolt diameter—.697 in.

Lug diameter—.987 in.

Bolt face: type—counterbored
depth—.147 in.

MAGAZINE

Length—2.86 in.

Depth—2.09 in.

Capacity: .222 Remington—5
.308 Winchester—4
6.5 Remington Magnum—3

WEIGHT

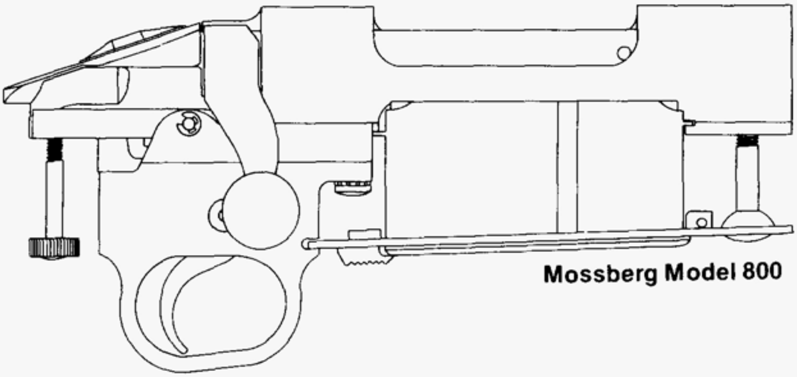
Receiver group (with recoil bracket)—15.5 oz.

Bolt group—11.4 oz.

Magazine/floorplate group—4.5 oz.

Total action weight—31.4 oz.

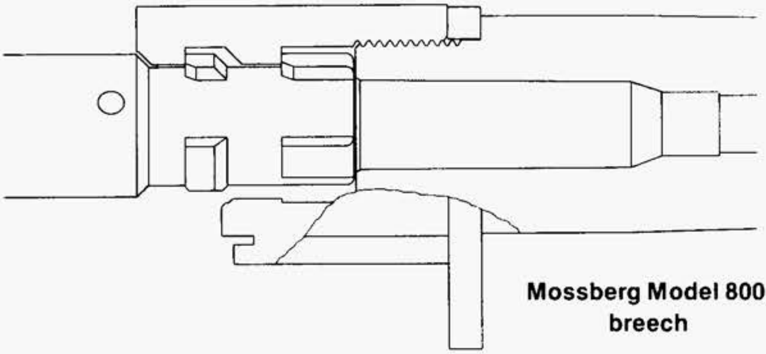
13
Mossberg Model 800



Mossberg Model 800

Mossberg finally got into the field of centerfire bolt-action rifles by a perhaps unlikely route. Montgomery Ward wanted a moderately priced bolt action to fill out their Western Field line of Mossberg-made sporting arms. Design work started in 1963 and principally involved two men, Louis Seecamp, an "old school" German gun designer who had emigrated to this country in 1959, and Carl Benson, Mossberg's Chief Engineer for many years.

The Model 800 evolved more or less as a combination of features from two previous firearms: a hand-made rifle built by Louis Seecamp during the period 1956–59, and Carl Benson's Model 385 bolt-action shotgun introduced by Mossberg in the early 1960s. Features carried over from the Seecamp prototype included the overall exterior shape and style of the action, the six-lug locking system with full-diameter bolt, and the extractor-ejector arrangement. From the Model 385 were patterned the sliding safety,



Mossberg Model 800, breech

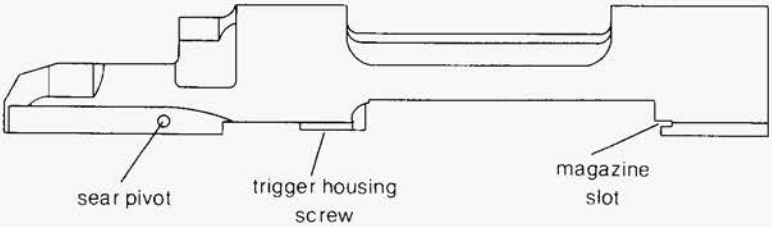
die-cast nylon trigger housing, plunger-type firing pin, and trigger bolt stop.

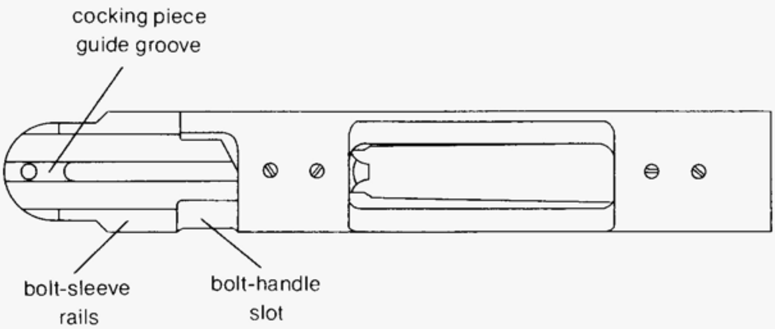
Introduced in 1965, the Model 800 is a trim action, intended for popular medium-length cartridges like the .243 and .308 Winchester.

The breeching pattern is a simple one. The cartridge base seats in a counterbored bolt face, broken only for a narrow extractor slot and containing a Remington-like plunger ejector. The tiny extractor is spring-urged slightly forward of the bolt nose, but cams flush during lockup, thus not interfering with a close breech fit.

The close relationship between a flat-nosed bolt and squared-off barrel gives an effective breech. There is not the extra strength margin of a shrouded bolt nose as in a Remington or Weatherby system, yet the clean and simple construction possible makes it the most widely used centerfire bolt action breeching pattern today, also currently used by Winchester, Savage, Ranger, Champlin, Voere, Husqvarna (M8000), Mauser (M2000), and Tradewinds (M600).

The receiver is basically cylindrical, but with a heavy bottom rib. This cross section is already cold drawn in the chrome-moly barstock Mossberg receives from the mill and so machining is really no more difficult than with a pure cylinder, as only the upper half of the receiver is ground and polished. This technique of using drawn shapes to minimize machining is applied several places in the Model 800, and is, in fact, a characteristic of Mossberg firearms, much as investment castings are heavily used for the Ruger line.



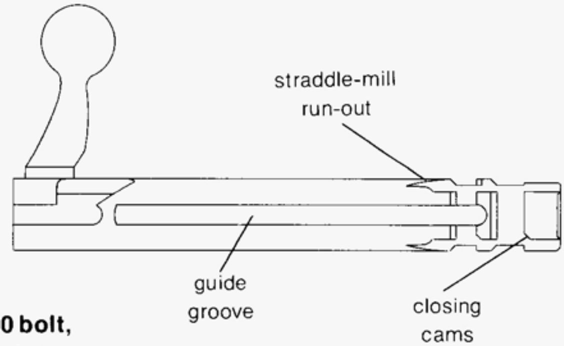


The receiver rib adds extra metal for guard screw engagement and also extra rigidity for solid barrel support. A Remington-like bracket of extremely large size clamps in front of the receiver as the recoil lug. With more than three times the bearing surface of the Mauser M98, it allows an inherently powerful stock configuration that requires no cross-bolting.

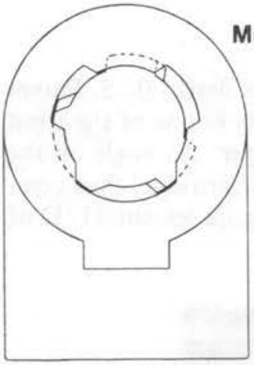
The bolt is a Weatherby-like full-diameter type machined also from chrome-moly barstock. A cast bolt handle is resistance brazed in place with a wafer of silver alloy after heat treatment of the parts. The handle is clamped onto the bolt by the electrode and heated rapidly to avoid softening the cams. The procedure is quick, but does not yield nearly as strong a joint as possible with the high-temperature copper brazing processes. After cooling, each joint is checked by hitting the handle with a plastic mallet. Those which come off are simply cleaned and re-cycled.

The handle is spindly, swept forward on some rifles and butter-knife shaped on others. Neither matches the sturdiness of the bolt body, and so detract from the action's overall appearance.

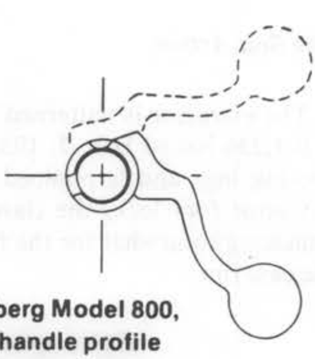
The full-diameter construction eliminates broaching long raceway channels in the receiver, leaving mostly a straight cylindrical bore. Only about a half inch of broaching is required in the receiver ring to form the locking seats, and this usually expensive double-broach procedure is easily accomplished in the Model 800 with a single pass.



Model 800 bolt, bottom view



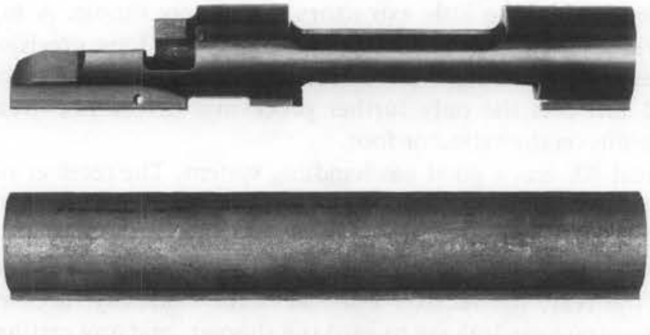
Mossberg Model 800,
lug/seat layout



Mossberg Model 800,
bolt-handle profile

The shallow bolt lugs also allow a strong receiver-ring structure. Despite a small 1 1/4 in. receiver diameter, the walls are more than .2 in. thick. This combines with the small inside surface area to give superior resistance to expansion in case of a ruptured cartridge.

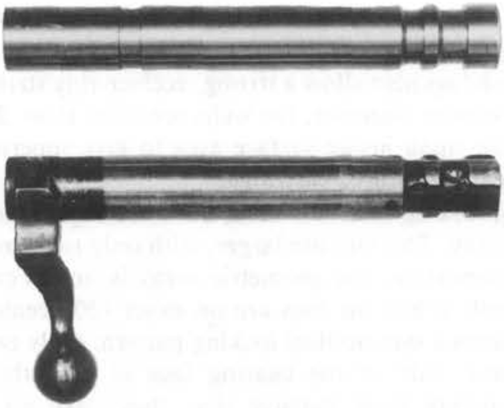
A multiple-lug locking system is used, but differing considerably in detail from the Weatherby. The lugs are larger, with only two rows for a total of six lugs. More important, the geometric array is not as carefully and efficiently patterned. While the lugs are on exact 120° centers, an oversize bottom lug prevents a symmetrical locking pattern. Only two lugs are fully seated, with about half of the bearing face of the other four wasted. Consequently, despite their massive size, they have no more effective bearing area than many simple Mauser locking patterns. Total bearing of this six-lug system is .07 sq. in., adequately strong, but far short of its potential.



Mossberg Model 800
Receiver in process

Shear area, which in contrast is little affected by the exact locking pattern or the lug heights, totals a massive .63 sq. in., about double that of the Mauser M98, and probably greater than any other purely front-locked turnbolt action. The almost 10 to 1 ratio of shear to bearing area is unusually extreme. Most of the locking systems examined in this book are closer to 5 to 1.

The extractor is patterned after an early Winchester design (U.S. Patent 2,101,236 issued Dec. 7, 1937 [F. F. Burton]). It seats in one of the front locking lugs and is retained by a small spring plunger. An angle on the extractor foot locks the claw inward against a stuck cartridge, thus compensating somewhat for the fact that its narrow claw grips less than 1/12 of the case rim.



Mossberg Model 800
Bolt in process

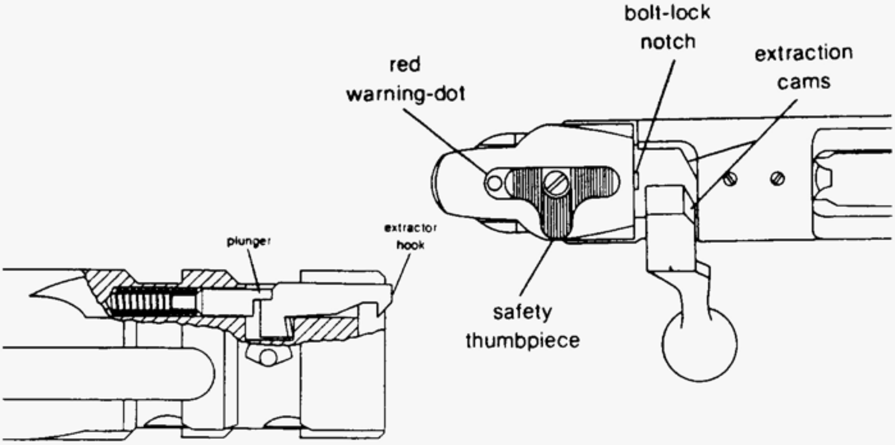
Manufacture of these little extractors is uniquely simple. A high-speed cutter literally slices them off by the hundreds from long precision-drawn steel shapes imported from West Germany. The as-drawn tolerances are so close (.002 in.) that the only further processing before heat-treatment is milling a radius on the extractor foot.

The Model 800 has a good gas-handling system. The receiver ring is left solid for strength, while the bolt has a small vent facing the ejector port. At the rear, the bolt interior is shrouded by a solid bolt sleeve.

Outside the bolt, the receiver ring is partially plugged by the large bolt body. To the rear, the receiver bore lacks the usual lug raceways which would concentrate gas leakage toward the shooter, and any getting past the bolt clearance is diverted by the bolt sleeve flanges.

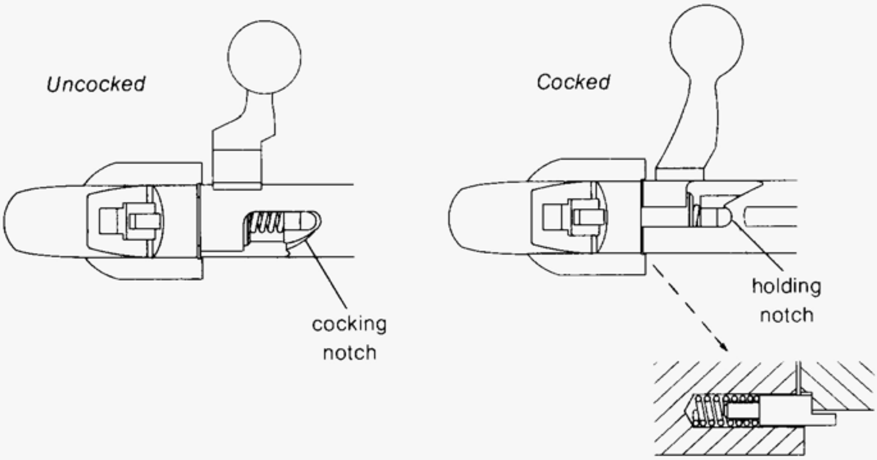
Typical of the newer actions with less than a full quarter-turn bolt rotation, the camming power of a Mauser action is missing. For example, the Mauser M98 extracts the fired case more than 1/8 in., about twice that of the Model 800. On closing, the Mauser cams are effective more than four times the distance of those in the Mossberg.

Bolt lift cams the cocking piece into a holding notch to lock the firing pin against accidental uncocking. Since the bolt sleeve and cocking piece don't


bolt-lock notch
red warning-dot
extraction cams
plunger
extractor hook
safety thumbpiece

Mossberg Model 800, extractor

index together, however, this does not prevent the bolt sleeve from turning, and a separate lock is necessary, described later. Compression during bolt lift is .36 in., which exceeds the total striker fall. The mainspring thus relaxes slightly during closing, an inefficient arrangement.


Uncocked
Cocked
cocking notch
holding notch
Bolt-sleeve lock

Cams milled on the locking lugs advance the bolt .06 in. during closing. A powerful leverage is achieved, yet, as with the Weatherby Mark V, this camming is much too short and balking results unless the bolt is slammed forward.

The magazine is a top-loaded double-column type, with sheet-metal construction throughout. The floorplate assembly is also sheet metal, except for the molded-plastic trigger bow. The floorplate frame is supported by the front guard screw and a notch in the trigger housing. A small bushing in the stock behind the trigger housing provides the rear guard-screw escutcheon.

The bolt sleeve is a large casting, shaped something like a turtle shell to accommodate a unique safety arrangement described below. It threads into the bolt to provide mainspring purchase and shroud off escaping gas or a rearward-driven firing pin. A spring plunger in the left flange functions basically like the Mauser M98 bolt-sleeve lock, but is much smaller and retained only while pressed against the bolt rim. Care is necessary to prevent its loss when unthreading the bolt sleeve.

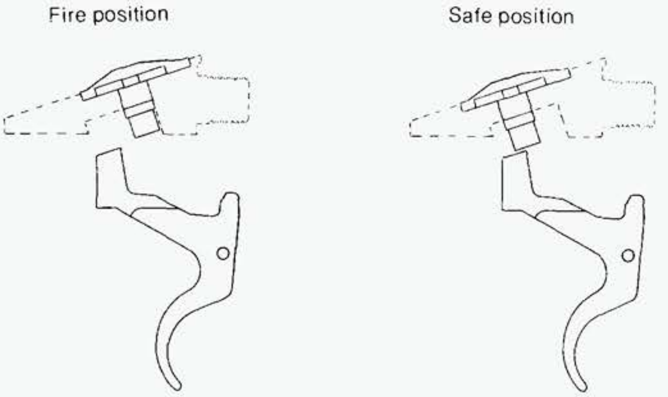
The Model 800 uses the basic safety developed for Mossberg's Model 385 bolt-action shotgun. This sliding thumbpiece pattern, found on much of Mossberg's current firearms line, resembles the classic safety of the double-barreled shotgun, and is certainly one of the most convenient and natural systems for quick thumb operation when the hand is positioned for firing.

Application required some rearranging of the conventional Mauser pattern. The bolt sleeve was made solid at the rear and curved down to blend with the stock. This in turn led to the adoption of an Arisaka piston-type firing unit described later. A sliding thumbpiece was placed on top of this bolt sleeve, yet it had to lock the trigger. Mossberg did not want to lock the firing pin directly, as had always been done with bolt-sleeve mounted safeties, in order to avoid operating against the mainspring. Thus positive action was sacrificed for operating ease.

Operation of the safety is shown in the drawings. The trigger piece projects upward at the rear where it can be blocked by a lug fixed underneath the thumbpiece. Two detents result from shallow holes in the thumbpiece underside which engage a spring-loaded ball swaged into the bolt sleeve. At the rearward position, the lug covers and blocks the trigger. Moved forward, it shifts out of interference, and at the same time exposes a red warning dot.

Operation of this safety is easy and silent, yet it really cripples the trigger. Because it is not linked directly to the trigger by way of the housing, there is little dimensional control between the parts, and an enormous trigger engagement is required to compensate. This in turn led to the addition of an intermediate connecting piece which Mossberg terms the *trigger-sear*. This third piece converts much of the extra movement to free slack, which at least—like the old military triggers—makes the long pull less objectionable. Mossberg later refined this three-part trigger somewhat for the Model 810 by use of a trigger counterspring, as described in a later chapter.

An ironic footnote is that after patterning so much of the Model 800 to accommodate this safety location, Mossberg's latest thinking, represented

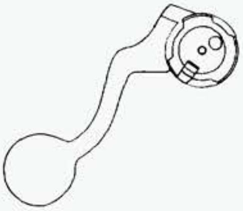


Mossberg Model 800, operation of safety

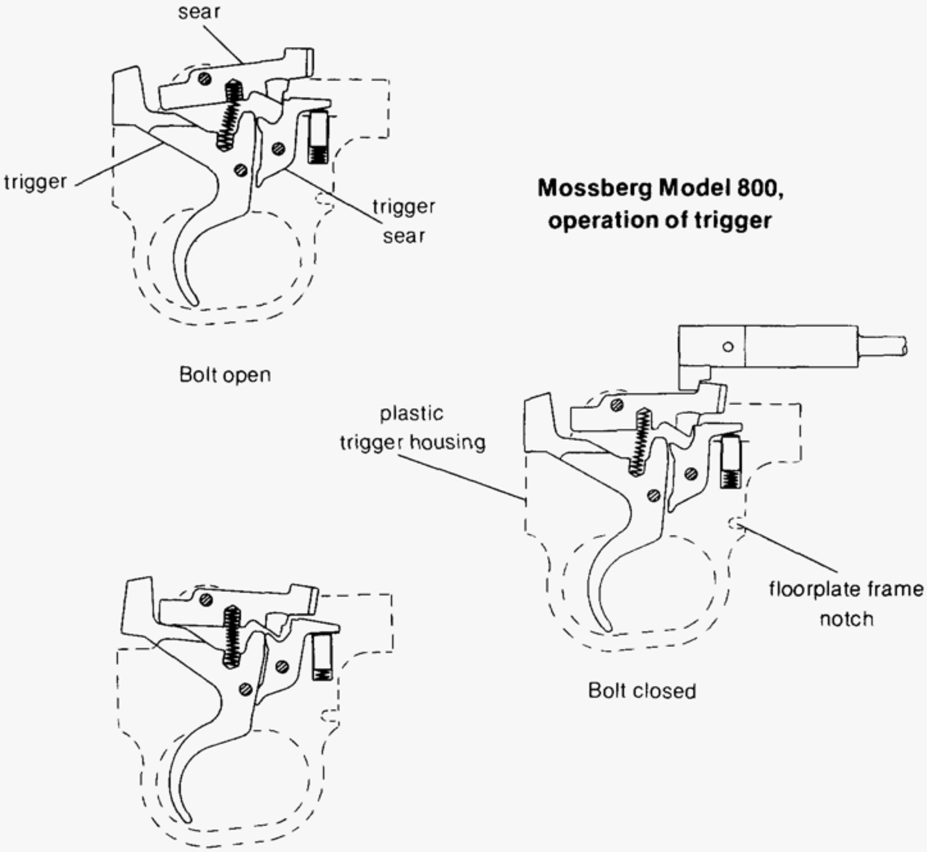
by the Pedersen Model 3000, moves it off the top of the bolt sleeve and down to a more traditional position on the side. It turns out that low-mounted scopes make the bolt action a somewhat different problem than the hammerless shotgun.

Functioning of the Model 800 trigger is shown in the accompanying drawings. The sear is supported by the trigger-sear, which in turn is controlled by the trigger. In a pure functional sense, it is not really a three-lever trigger as described in the Appendix, since only one of the levers is in the override circuit.

The trigger housing is molded-plastic, attached by a cross pin and machine screw, and extending down to form the trigger bow. A hole in the side of this housing shows sear engagement, although, as shown, no adjustments are provided.



Mossberg Model 800, bolt face



Mossberg Model 800, operation of trigger

Bolt open

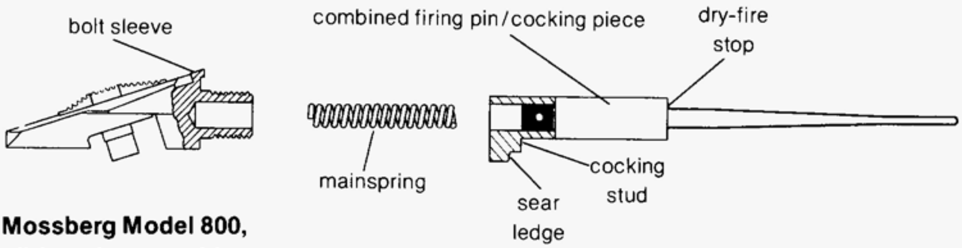
Bolt closed

Bolt released

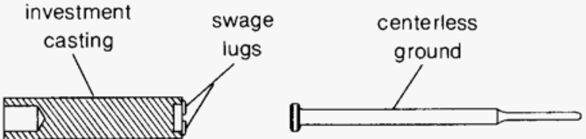
The sear also rides in a groove under the bolt to steady and control its movement. Pulling the trigger fully forces the sear down flush for bolt removal. The sear automatically overrides in the other direction, a convenient feature.

This use of the sear further limits trigger performance, which obviously got a low priority in the original design layout, intentionally or not. Because of its bolt-stop role, overtravel or *backlash* cannot be adjusted out of the trigger. Also, of course, it is subjected to a pounding when the bolt is worked hard, thus precluding the fine-tuned precision necessary for top performance.

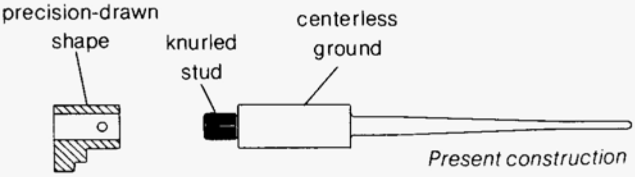
The Model 800 firing pin is a hollow plunger positioned forward of the mainspring, similar to that in the Arisaka. The cocking piece and striker tip are fabricated into a light fast-moving part. Weight is less than 1.5 oz. Originally the striker shaft was swaged into an investment-cast cocking piece. In 1968, a less expensive and more precise construction was substituted. A precision-drawn shape is used for the rear section of the cocking piece. The front is centerless ground, integral with the striker shaft and with


bolt sleeve
combined firing pin/cocking piece
dry-fire stop
mainspring
cocking stud
sear ledge

Mossberg Model 800, firing pin assembly


investment casting
swage lugs
centerless ground

Swaged firing pin (pre-'68)


precision-drawn shape
knurled stud
centerless ground

Present construction

a straight-knurled stud at the rear to form an interference fit with the drawn cocking piece. When the two are pressed together the knurls engrave to form a very tight joint, yet without distortion. A cross pin then forms a permanent assembly.

A tiny but very stiff mainspring nests between the bolt sleeve and firing pin. Counterbores on each end provide its only support, with no firing pin shaft per se. This small size dictates a very steep rate (almost 50 lb./in.), many times that of a more conventional mainspring and unfortunately creating a sharp and difficult cocking action. As an example, during bolt lift, mainspring load in the Springfield M1903 goes from 10 to 12 lb., a smooth gradual increase. The Model 800 figures are 13 and 28 lb. This, combined with a shorter lift, precludes a smooth opening cycle.

SUMMARY

The Model 800 is interesting, but lacks refinement. Operation is coarse, and while it has some strong features, the actual locking and camming systems are inefficient and not nearly as strong as they could be. When developing the longer Model 810 action, Mossberg ended up with an almost completely new design. The Model 800 continues for the shorter cartridges, but one must suspect that role will one day be taken over by a short Model 810. The following summarizes the strong and weak points of the Model 800 action:

Strong points:

1. Good gas handling.
2. Fast lock time.
3. Simple and easily serviced design.

Weak points:

1. Rough and heavy bolt operation.
2. Narrow extractor claw.
3. Trigger-block safety.
4. Non-adjustable trigger with sear bolt stop.

MOSSBERG MODEL 800

Dimensions

OPERATING

Extraction: set-back—.06 in.
leverage—8 to 1

Chambering: cam-forward—.06 in.
leverage—9.5 to 1

Bolt rotation—70.5°

Bolt travel—3.88 in.

Operating forces: bolt lift—9.5 lb.
press-forward—15 lb.
bolt turndown—5 lb.

Cock-on-opening; .312 in.
mainspring compression
proportioned as follows:
opening—.357 in.
closing— -.045 in.

IGNITION

Firing pin travel: at impact—.240 in.
dry-fired—.312 in.

Lock time—2.4 ms.

Impact velocity—17.5 ft./sec.
energy —77.4 in.-oz.
impulse —.74 oz.-sec.

Striker/firing pin hole diameters—.075 in./.081 in.

RECEIVER

Overall length—7.95 in. (8.13 in. with recoil bracket)

Length of loading/ejection port—2.72 in.

Ring diameter—1.240 in.

Barrel/receiver threads: designation—⅞-18 N.S.
engagement—.425 in. (7.5 threads)

Recoil lug: width—1.25 in.
thickness—.185 in.
bearing area—.83 sq. in.
clearance from magazine—1.13 in.

Guard screws: front—¼x32
rear—10x32

Scope mounting—6x48 screws

BOLT

Lug shear area—.633 sq. in.

Lug bearing area—.067 sq. in.

Bolt diameter—.747 in.

Lug-recess diameter—.614 in.

Lug diameter—.747 in.

Bolt face: type—counterbored
depth—.111 in.

MAGAZINE

Length—3.01 in.

Depth: front—1.92 in.
rear—1.99 in.

Capacity—4

WEIGHT

Receiver group (with recoil bracket)—18.7 oz.

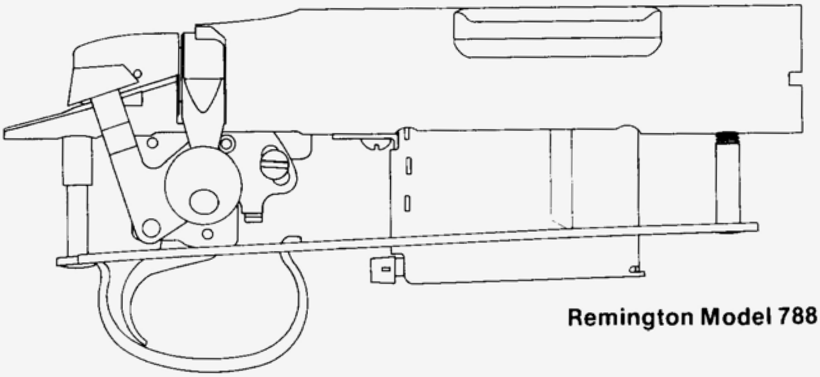
Bolt group—13.8 oz.

Magazine/floorplate group—5.2 oz.

Total action weight—37.7 oz.

14

Remington Model 788 (Rimless Versions)



Remington Model 788

Charles Morse and Wayne Leek started work on the Model 788 in 1964. It was the first really new Remington centerfire bolt action in almost twenty years, and only the extractor and ejector carry over from previous Remington practice. Since Remington machines the critical-strength parts from solid steel, the tooling for high-production manufacture at Ilion ran into millions of dollars. In order to justify these costs, Remington engineers integrated both a centerfire and rimfire series into the new design. In addition, the centerfire version had to adopt to rimmed cartridges, since Remington had long wanted to market a rifle in the venerable .30–30 Winchester. The basic design thus required extreme versatility, and as will be seen, the resulting compromises strongly shaped the ultimate layout.

Multiple-function was not the only influence. In non-critical areas, concept planning from upper management called for the use of as many sintered-metal parts as possible, since one of Remington's divisions specializes in this field. Finally, specific emphasis was placed on improved accuracy in a production bolt rifle. Although not active for many years, Wayne Leek, like Mike Walker, was one of the original bench rest competitors, and has since always maintained a strong interest in this aspect. New features directed toward this end included an extended barrel shank, thick-walled receiver, and high-velocity firing pin.

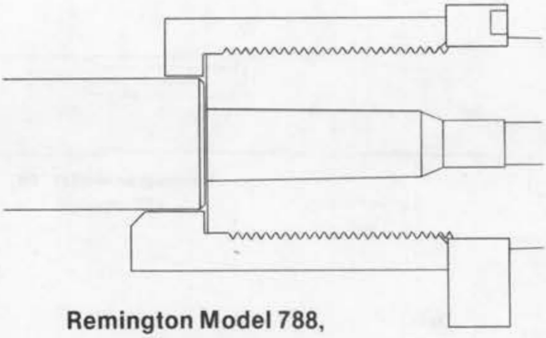
From a manufacturing standpoint, the 788 centerfire and 580 rimfire form a family of firearms. While few parts are actually interchangeable between the two series, the shapes, contours, and angles are alike, different mainly in scale. Thus only one basic group of machine tools is needed, with relatively minor adjustments involved in switching from one model to another. The whole process is accomplished in a matter of hours.

This Remington *family of guns* concept, which goes all the way back to the days of reconversion and modernization, also has its pitfalls. Besides the inherent design compromises involved, particularly when trying to link a centerfire and rimfire series together, the concept of common tooling investment means that if one particular version fails commercially, it may take a whole series of firearms down with it.

When introduced in January, 1967, interest in the Model 788 centered on the rear multiple lugs and heavy-walled receiver. Equally interesting, however, is a close tailoring of action and cartridge. The 788 is built for six rimless cartridges—.222 Remington, .223 Remington, .22/250 Remington, .308 Winchester, .243 Winchester, and 6mm Remington. Most actions cover these with one bolt/receiver combination, simply modifying the magazine. There are three distinct 788 configurations. The .222, .223, and .22/250 have a bolt/receiver length of 5.17 and 8.29 in. respectively, but the.22/250 has larger magazine and ejection ports. The remaining rimless versions are all identical to each other except for the cartridge box itself, with bolt/receiver lengths of 5.47 and 8.59 in. This custom tailoring is a useful by-product of the simplified design pattern.

It was previously noted that Mauser's *inner-collar* breech (U.S. Patent 579,994 issued April 6, 1897) and Remington's *counterbore* breech (U.S. Patent 2,585,195 issued Feb. 12, 1952) were functionally similar, with the bolt-head shroud part of the receiver in one and the barrel in the other. From a manufacturing standpoint, the 788's rear lockup happened to favor a receiver-ring collar, rather than barrel counterbore as before (Remington's 1952 patent actually showed both patterns). So in a way it becomes a modern version of the M98 breech, without feed, extractor, or ejection cuts in the bolt face counterbore.

It thus equals the Model 700 breech, and in fact gives an even stronger receiver ring. Not only is the inner collar a reinforcement, but the rearward

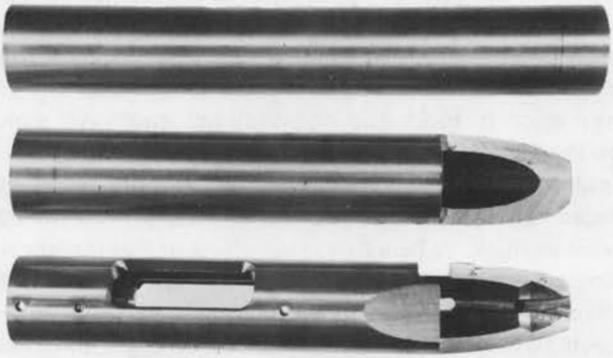


Remington Model 788,
.222 breech

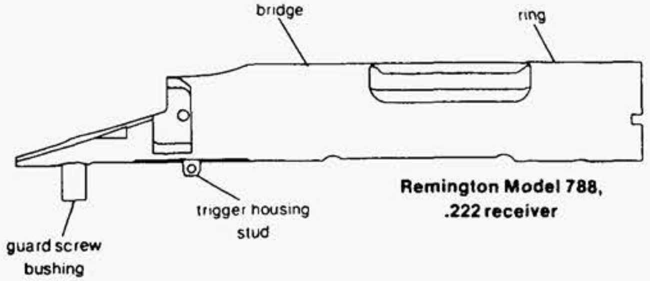
locking members allow smaller internal diameters in the receiver ring. Finally, the rearward shift of the breech, combined with the long barrel shank, seats the barrel unusually deep into the receiver. As the drawings show, the receiver ring almost entirely encircles the .222 chamber.

The 788 receiver is cylindrical, machined from chrome-moly barstock. The bars are drilled and bored, but then instead of broaching, the short lug raceways are cold-forged over a spline-shaped mandrel with multiple hammers in a similar process to that used in forged rifling. The receiver blanks are then cylindrically ground to establish outside dimensions and relief annealed. A locating slot is next milled in the front face as the reference for subsequent machining operations.

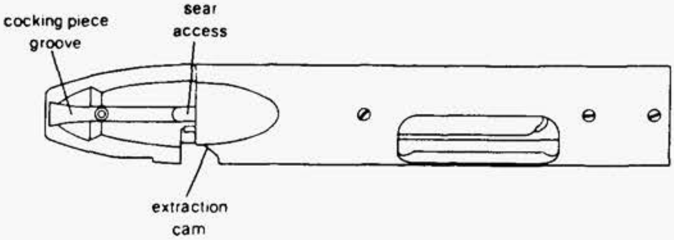
A vertical cam-controlled boring machine cuts the circular grooves to complete the locking seats. The receiver is then finished on three automated Tri-Ordinate stations. A surprising fact is that the 788 receiver actually requires more machining operations, and is thus more costly to make, than the Model 700 receiver. The same applies to the bolt. Thus, although engineering and manufacturing were supposed to be closely integrated in the 788 project, this is obviously one aspect which did not work out quite as well as Remington might have liked.

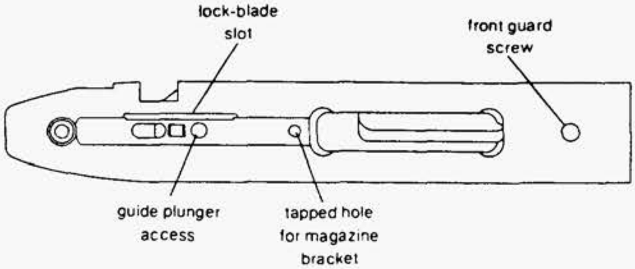


Remington Model 788
Receiver in process


bridge
ring
guard screw bushing
trigger housing stud

Remington Model 788, .222 receiver


cocking piece groove
sear access
extraction cam

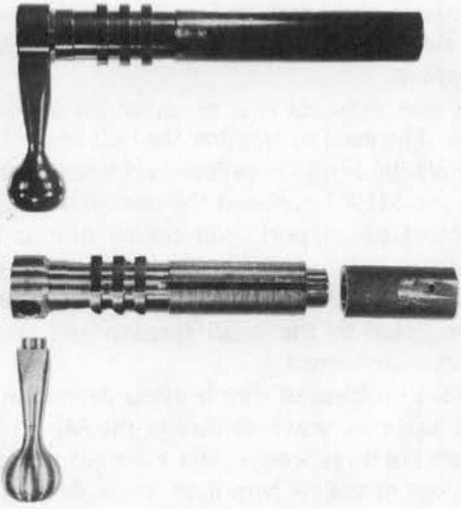

lock-blade slot
front guard screw
guide plunger access
tapped hole for magazine bracket

A bracket recoil lug is clamped to the receiver by the barrel. In order to allow this clamping, the inner collar cannot form the barrel seat, as it does in the Mauser M98, and instead a .010 to .015 in. clearance is allowed. Two lugs are upset on the sides of the bracket to fit notches milled in the face of the receiver ring. While this system proves useful in alignment when the 788 is rebarreled by gunsmiths, at Remington this is only a secondary purpose for these notches. Their primary function is to orient the receiver during machining, since it lacks the conventional raceways which serve that purpose in the Model 700.

Since not intended for magnum cartridges, the recoil bracket can be smaller faced than the Model 700's. Yet because it is sintered metal, it is almost twice as thick. A beneficial side effect of this thickness of course is a stiffer-barreled action which helps accuracy. The amount of wood backing up this bracket varies, 1.6 in. in the .222/.223 versions, and 1.4 in. in the others. Each gives more than enough recoil strength to eliminate any need for stock reinforcement.

Two guard screws are used, with a special bushing pressed into the rear tang, as it is so thin at this point that it would otherwise be difficult to control guard screw and stock dimensions closely enough. Despite a smaller diameter, the 788 receiver has more useful bedding surface than the Model 700, primarily because of its narrow magazine, wide tang, and lack of cross pins for the trigger and bolt stop.

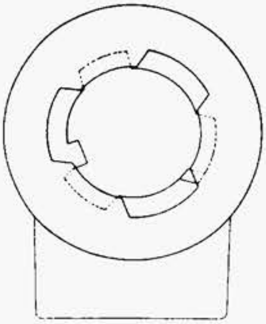
The bolt is fabricated of three pieces: the bolt head, the bolt cylinder which backs it up and carries the locking lugs, and the bolt handle. Each is machined from carbon-steel barstock. Because of the extensive machining in the 788 bolt, free-cutting resulfurized steel is used, instead of the high-strength chrome-moly steel used in the Model 700 bolts. After machining, the assembly is furnace-brazed together with copper alloy, as in the Model 700, and then heat treated.



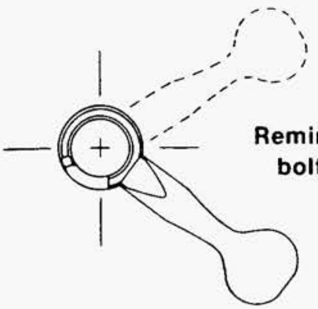
Remington Model 788
Bolt in process

There are nine rear-positioned locking lugs. Each is very small and narrow, yet they combine for a locking system of exceptional strength. The lug shear area adds up to .38 sq. in., but the big item is bearing, which comes out to .15 sq. in., double that of many other actions.

Rear lockup dominates the design of the 788. The lugs are at the rear to give a similar design pattern, and thus allow common tooling with the 580 rimfire series. Analysis can reveal some of the practical advantages and limits of a modern rear-locked centerfire action.



Remington Model 788, lug/seat layout

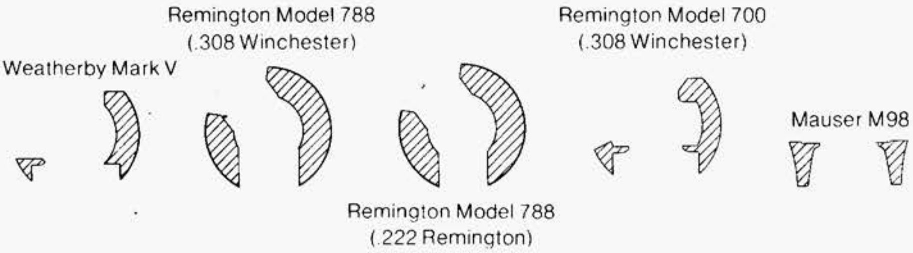


Remington Model 788, bolt-handle profile

On the plus side, the rear lugs allow adaptation to rimmed cartridges, which feed much better without locking cavities to travel over. A somewhat shorter bolt stroke is also possible. Finally, with less potential surface area in the receiver ring for a burst cartridge to act upon, safety factor and strength can improve.

Rear locking also presents two potential problems; bolt stability and linear deflection. The need to stabilize the bolt under firing led Remington to adopt a multiple-lug array, in order to achieve an extra-stable tripod-like support. When the M1903 replaced the one-lug Krag, its dual lugs gave a more balanced locking support, eliminating non-uniform strains during firing. An evenly spaced three-lug array like the 788's gives the most stable and uniform support possible. Any tendency to buckle or jam under load was further minimized by the small ejection and magazine ports, which allow greater bolt encirclement.

More basic is the problem of simple linear deflection. The 788 receiver is more than half again as heavy as that in the Model 700, with a massive midsection. There are no raceways, and the walls are almost 5/16 in. thick. Yet, while this does of course help limit linear deflection somewhat, there was no practical way to achieve a rigidity equal to that of a front-locked action.



Scale comparison of receiver rails

The 788 bolt actually compresses more than the receiver stretches, and both would have to be made unrealistically massive to compensate. This is not a function of the strength or grade of steel, since within their elastic range, all have virtually the same modulus or stretch characteristic. A high-strength heat-treated steel simply remains elastic longer. Few useful metals exceed steel's 30,000,000 lb./sq. in. modulus.

Stretch of the 788 during firing can be roughly computed—about .001 in. per 1,000 lb. back thrust. Actual tensile measurements made at Remington's Ilion laboratory confirm this figure, giving approximately the same results, just slightly higher. This stretch may seem negligible, yet it far exceeds the give in a front-locked action. It is more than five times that of the Model 700. What are the practical effects? None, insofar as the strength, safety, and accuracy of the 788 is concerned. It can affect reloading ammunition. While still not required after each firing as with some non-bolt guns, occasional full-length resizing may be necessary in certain calibers to maintain smooth operation. Remington factory tests indicate that .22/250 cartridge cases, for example, required resizing each five to ten firings.

Finally, the need for extra-uniform locking support with rear lugs had an indirect effect on cartridge ejection in the 788. The 120° locking-lug array is specially aligned with respect to the ejection and magazine ports, and the size of the two receiver rails had to be proportioned accordingly. This required cutting the ejection port on a very high angle.The ejected cases come out at such a high trajectory that they tend to strike the windage knob of a scope and fall back into the receiver. Remington advised the various scope-mount manufacturers of this problem before the rifle's release, and recommended developing special full-bridge mounts with an angle under the right side, to deflect ejected cartridges away from the scope. Needless to say, all mounts available for the 788 do not follow this pattern, and in these cases perhaps the easiest solution is simply to rotate the scope 90°

The magazine is a detachable single-column type, which lacks the capacity of a double-column magazine but has advantages. Feeding is more direct, and the narrower cut removes less of the receiver bottom. To illustrate, in .308 Winchester caliber, the Model 700 has a wedge-shaped magazine cutout, .975 in. wide at the rear by .855 in. at the front. The 788 has a straight slot, only .635 in. wide and thus occupying about 25% less surface.

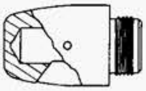
The cartridge box is folded sheet steel and supported by a heavy receiver-mounted bracket which makes attachment and removal easy and positive, without the play and imprecision of many detachable magazine systems. The floorplate frame is also sheet metal, attached by the front guard screw and a small wood screw. Since the cartridge box is bracket-guided, this frame simply dresses up the fit with the stock. The trigger bow is a separate part, tabbing into the floorplate frame and flanged for the rear guard screw.

Neither the bolt nor receiver has gas-release ports. Gas blockage, on the other hand, is thorough, with the shrouded breech up front and an enlarged bolt collar at the rear to shroud the bridge. The bolt interior is protected by a reduced-size firing pin hole (.066 in.) and by a flat firing pin which presents less tendency to being blown rearward by pressure and is blocked by the solid bolt sleeve.

Remington theories on gas handling differ from much of their competition—and most gun critics—but are based on extensive testing. Basically, they are that strength is achieved primarily by blocking, not venting, gas. Pressure must be blocked immediately at the breech, which is the function of their patented shroud-type bolt nose which plugs the barrel. Here, diameters and areas are smallest.

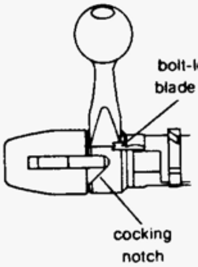
If pressures can freely enter the receiver-ring interior, superior strength is not possible. Stress loadings are high, particularly in front-locked actions where the inside is carved out by locking cavities. Extra-large diameter bolts, and other schemes to trap pressure within the receiver ring, simply aggravate the problem in Remington's view. On the other hand, receiver-ring ports do little good. The tiny gas port in the Model 700 receiver ring is, in fact, nothing more than a harmless concession to the theories of the marketing department. It offers an almost negligible escape path compared to the lug raceways and bolt clearance anyway.

The shrouded bolt sleeve of the Model 788, which is machined from solid steel bar, is a real strong point, and a definite improvement over previous Remington centerfire rifles. Field stripping, which always gets tricky when the rear of the bolt sleeve is closed off, is accomplished in the 788 bolt by means of a small cross hole which registers with one in the cocking piece to permit locking the firing pin in the retracted position.

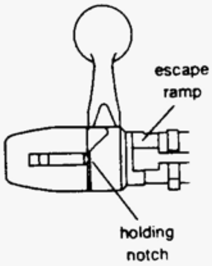


Remington Model 788, bolt sleeve

Like many multiple-lug actions, weak camming hamstrings the efficiency of the 788. With less bolt rotation available, a sacrifice is necessary somewhere—either in the cams or bearing faces. Remington opted for strength, and the 788's bearing strength is impressive, but at the same time it lacks the kind of smooth, slick, and powerful camming action of most two-lug Mauser actions.



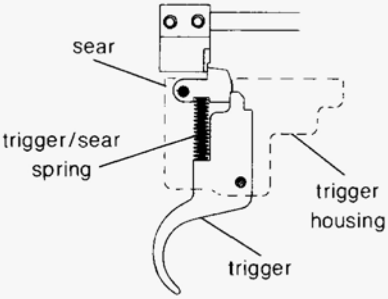
Uncocked



Cocked

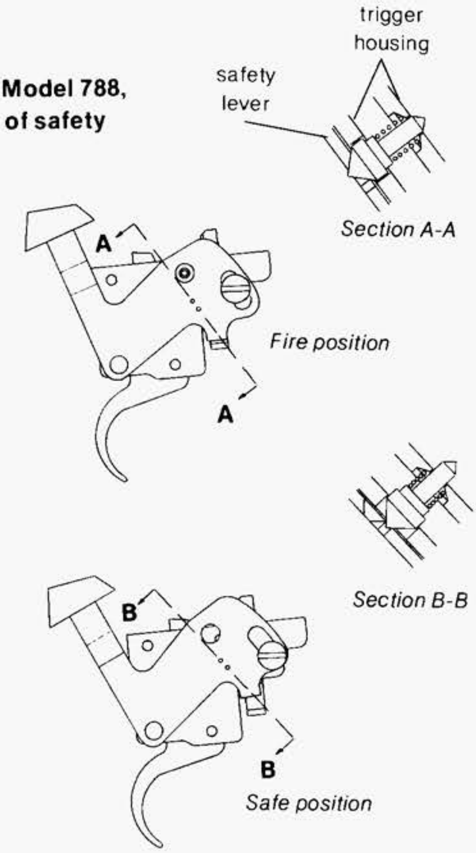
Extraction set-back is .11 in. at a 5 to 1 leverage, and the closing cams advance the bolt only .08 in. at a 6 to 1 leverage. Both cam sets are unusually weak for a bolt action, both from the standpoint of distance cammed and mechanical advantage achieved.

The 788 has perhaps the ultimately simple override trigger, with even a common spring for both the sear and trigger piece. Both of these are sintered metal, while the housing is a zinc casting attached by a cross pin and set screw combination. The entire unit is an economy job, lacking adjustments. This arrangement of parts, with the common spring in between, is virtually identical to that used in the single-stage trigger developed in the mid-1930s for the Oberndorf Mauser sporting rifles.



Remington Model 788, trigger assembly

The safety is a lever-operated crossbolt type. A small two-diameter plunger fits cross-wise to the trigger piece and is controlled by a pivoted lever which has two holes drilled into its inner side. With the thumbpiece drawn back to *safe*, the smaller hole registers with the plunger nose, positioning its larger diameter in front to block the trigger. Simultaneously, the upper tip of the lever locks the bolt from rotating. Moved forward to *fire*, the larger hole registers, allowing the plunger head to shift clear.

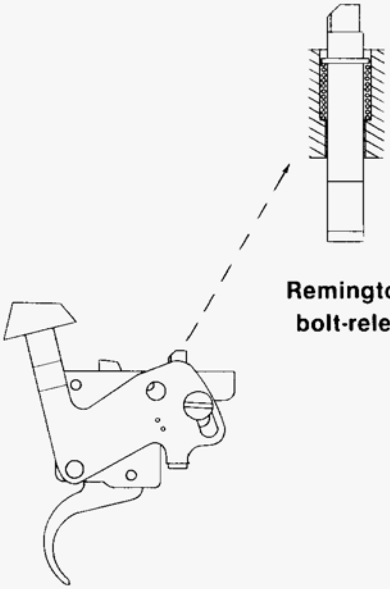


Remington Model 788, operation of safety

A trigger-block safety like this is not only less direct, and thus inherently less certain than other types, but it also limits trigger performance. There are, of course, reasons for its use. It is easy to make and operate. Since it only blocks the trigger, it can be attached in a variety of locations and requires no mechanical leverage.

Its intrinsic flaw is that it ties safety and trigger function together in a disadvantageous manner. The relatively fragile engagement between the trigger and sear becomes part of the safety linkage. If the safety is to have a high factor of certainty, there must be more trigger engagement than desirable from the viewpoint of a clean release. In comparison, both the direct and the sear, or semi-direct, type safety engage independent of the trigger.

The 788 bolt is guided by a spring plunger in the trigger housing which projects upward to engage a narrow groove in the bolt underside. Rearward movement is stopped by the bolt-head juncture, while a clearance slot on the other end permits bolt turndown. Up to this point, it is similar to the system in the Weatherby Mark V. The 788 unit, however, is superior. Its plunger is beveled for convenient bolt insertion. More important, even though fitted to the trigger housing, it is not tied to trigger function, and is actuated instead by the safety lever.

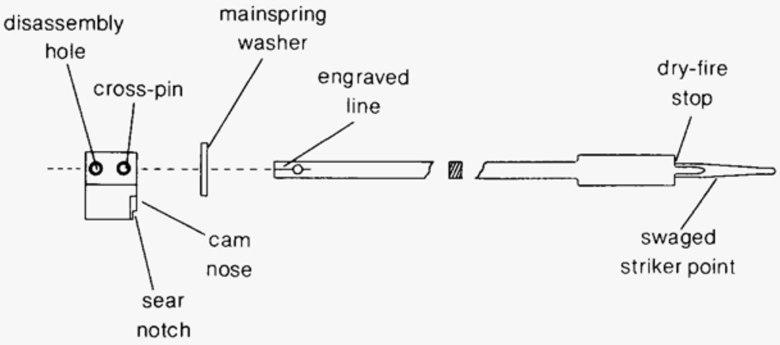


Remington Model 788, bolt-release position

With the bridge chopped up inside by locking grooves and raceways, and bored out at the rear for the bolt collar, little support surface remains for the bolt body. This is one area where the 788 lacks purist appeal. In contrast to the slick and solid piston-like feel of a well-tuned Model 70, Springfield M1903, or even Weatherby Mark V, the 788 bolt, once lifted, just seems to come loose from the receiver and clatters back to a stop. No really serious cramping results, yet neither is there the sure and positive feel traditionally demanded of a quality bolt action.

The firing pin is blanked from 1/8 in. steel plate, instead of machined from rod-form in the conventional manner. The striker section is then swaged to a round cross section, and the tip machined to the usual spherical shape. Besides the obvious economy, this unique construction offers an effective way to combine light weight with strength.

The mainspring is a long, high-suppression type, which remains so severely buckled during firing that friction is probably increased somewhat. Thus, the computed lock-time figures in the Summary, which are not



Remington Model 788, firing pin assembly

specifically corrected for friction, may be slightly fast. Actual Remington measurements for the 788 varied between 2.4 and 2.7 ms.

The pinned-on cocking piece is another sintered-metal part, of minimum size and weight like the firing pin. The combination of firing pin, cocking piece, and cross pin weighs only .8 oz. (compared to 3.4 oz. in the Springfield M1903 and 1.9 oz. in the short-version Model 700). The 788 thus has a true speed lock, with the power source (mainspring) weighing about one-third of the entire firing unit (compared to less than one-tenth in the M1903).

Small ridges within the cocking piece engrave the firing pin shaft during assembly, making possible a solid joint without close tolerances. With the cocking piece inserted from the front into the shrouded bolt sleeve, the bolt-sleeve bore becomes too large to support the mainspring, and so a small steel washer is inserted as a bushing.

A final item of interest is the small-diameter striker point, only .058 in. (compared to .075 in. in most centerfire bolt actions). This was not part of the original design concept, but evolved from problems getting a .075 in. tip to indent enough for reliable ignition in the 788. Regardless of the origin of this feature, it gives the bonus of increased safety. With a properly shaped tip, the small striker is no more prone to pierce the primer, and on the other hand, the small firing pin hole better supports the primer cup. It can be shown by calculation that it permits the primer to withstand about 15% higher pressure before blanking. Also, of course, if gas is released, much less reaches the bolt interior.

There are also a couple of potential drawbacks of small pins. Alignment is more critical for even ignition. Remington's design and production methods, however, easily assure the necessary concentricity. Tip breakage is slightly more likely, but again this has not proven a problem in the 788.

SUMMARY

The Model 788 is a strong action. On paper, it appears to be even stronger than the Model 700, although Remington engineers claim that in actual tests with pressures exceeding 250,000 psi, the Model 700 came out slightly better.

The 788 is also bulky. In .308 Winchester it weighs over 43 oz., almost 12 oz. more than the Model 600 and 8 oz. more than the Model 700. It also lacks the slick lines and smooth and positive functioning of a traditional Mauser-style two-lug action. Yet, considering the fact that it had to share the features of a rimfire, follow Remington's policy of machining major strength parts from solid steel, and sell at a very low price, it is a remarkably effective firearm. It compensates for some lack of refinement by features making it one of the most accurate of production rifles. The following briefly summarizes its strong and weak points:

Strong points:

1. Strong breeching and locking.
2. Rigid barrel/receiver makeup.
3. Fast lock time.
4. Rigid and easily bedded receiver.
5. Short bolt travel.
6. Shrouded bolt sleeve.

Weak points:

1. Lack of smooth and positive bolt operation.
2. Trigger-block safety.
3. Non-adjustable trigger.
4. Sheet metal trigger guard and protruding magazine.
5. Less rigid lockup than a front-locked action.

REMINGTON MODEL 788

Dimensions

OPERATING

Extraction: set-back—.11 in.
leverage—5 to 1

Chambering: cam-forward—.08 in.
leverage—6 to 1

Bolt rotation—68°

Bolt travel: .222, .223, and .22/250—2.90 in.
.308, .243, and 6mm—3.20 in.

Operating forces: bolt lift—9.5 lb.
bolt turndown—12 lb.

Cock-on-opening: .303 in.
mainspring compression
proportioned as follows:
opening—.254 in.
closing—.049 in.

IGNITION

Firing pin travel: at impact—.249 in.
dry-fired—.303 in.

	.222, .223, and .22/250	.308, .243, and 6mm
Lock time (ms.)	2.2	2.3
Impact velocity (ft./sec.)	20.9	19.7
energy (in.-oz.)	71.0	66.5
impulse (oz.-sec.)	.57	.56

Striker/firing pin hole diameters—.058 in./.066 in.

RECEIVER

Lengths (in.)	.222 and .223	.22/250	.308, .243, and 6mm
Overall/with recoil bracket	8.29/8.60	8.29/8.60	8.59/8.90
Loading/ejection port	2.14	2.25	2.73

Ring/bridge diameter—1.320 in.

Barrel/receiver threads: designation—1-20
engagement—1.1 in. (22 threads)

Recoil lug: thickness—.313 in.
bearing area—.35 sq. in.
clearance from magazine: .222—1.65 in.
.308—1.39 in.

Guard screws: front—¼ x 28
rear—12 x 28

Scope mounting—8 x 40 screws

BOLT

Lug shear area—.385 sq. in.

Lug bearing area—.154 sq. in.

Bolt diameter—.699 in.

Lug recess diameter—.675 in.

Lug diameter—.847 in.

Bolt face: type—counterbored
depth—.147 in.

MAGAZINE

	.222 and .223	.22/250	.308, .243, and 6mm
Length (in.):	2.31	2.40	2.88

Depth: front—2.10 in.
rear—2.17 in.

Capacity: .222 Remington—4
.308 Winchester—3

WEIGHT

	.222 Remington	.308 Winchester
Receiver group (with recoil bracket)	24.9 oz.	25.5 oz.
Bolt group	11.3 oz.	11.7 oz.
Magazine/floorplate group (with guide bracket)	5.2 oz.	6.0 oz.
Total action weight	41.4 oz.	43.2 oz.

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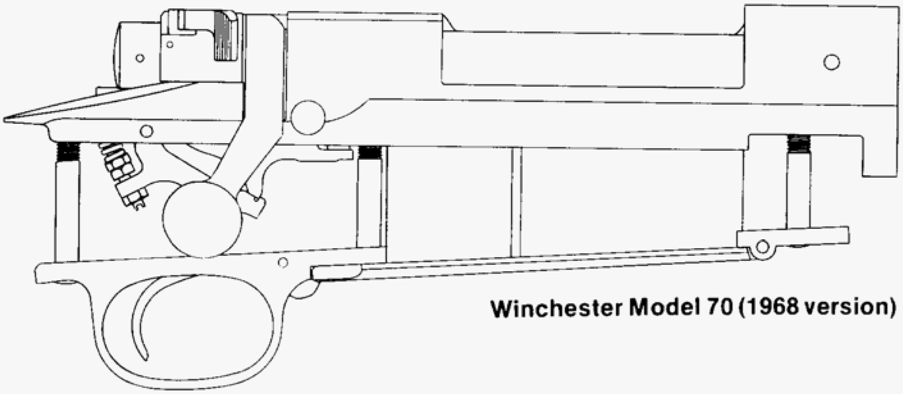
Winchester Model 70 (1968 Version)



Winchester Model 70 (1968 version)

By the 1960s, production of the Model 70 rifle, among other Winchester firearms, had long ceased to be a financially viable proposition. In 1961, the Olin Corporation brought in new management to revamp the entire firearms line. As part of the resulting *Product Improvement Program,* redesign of the Model 70 began in 1962.

The design work was by Bob Creamer and John Walsh, working closely under the direction of T. W. van Wilgen. In contrast to the reconversion and modernization program almost twenty years earlier at Remington which had led to the Models 721/722, this Winchester project had severe time and cost restraints. Further, the planning called for leaving many aspects of the original Model 70 unchanged, thus limiting possible design options.

Only about 1½ years were available for the entire project and thus a good deal of detail work was subcontracted out, including all the tolerance studies and manufacturing drawings which were prepared by the Pioneer Engineering and Manufacturing Co. of Warren, Michigan. The *new* Model 70 was introduced in 1964, the previous design becoming known as the pre-'64 version. Despite the short development time, the revisions were reasonably extensive. Areas which were not changed, such as the cams, are not included in this chapter. Except for going to investment castings, this also applies to the trigger and safety units.

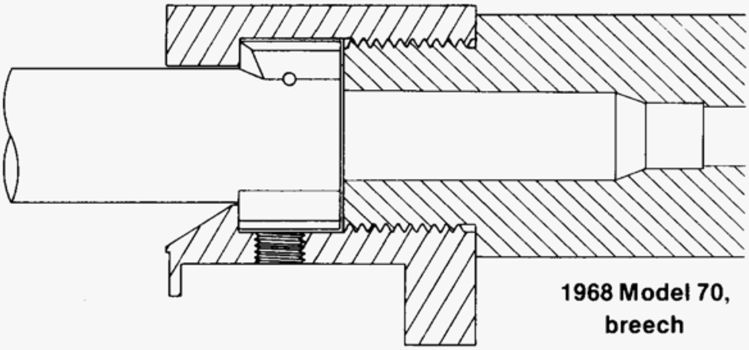
Many of the changes were improvements, not just cost short-cuts. Nevertheless, the new rifle suffered badly from an overall lack of finish. Its dull and rough exterior contrasted to the sleek and efficient appearance of the old version. The rifle consequently took a beating, even from loyal Winchester supporters.

Four years later, a third Model 70 was introduced, the 1968 version. That action is the subject of this chapter. It corrects most complaints with the action of 1964 by three main changes: An *anti-bind* feature steadied and smoothed bolt operation, and it now equals the classic pre-'64; a better quality magazine follower improved appearance and functioning; most exposed parts are nicely polished before blueing, and the bolt handle is knurled, greatly improving its looks.

By changes in fabrication, primarily the investment casting of many of the smaller parts, overall machining time was cut to less than half that of the pre-'64 action. At the same time, however, material costs almost doubled—Winchester buys the forgings and castings—somewhat diminishing the overall cost gains.

A new breech was the most important functional change from the pre-'64 rifle. In place of the Springfield-inherited cone, the barrel is now faced-off square and located within a few thousandths of an inch of the bolt, leaving very little unsupported cartridge head. While it still may lack some of the shrouding advantage of the *counterbore* breech as used by Remington and Weatherby (perhaps *double-counterbore* would be a more accurate term, since the counterbored bolt face is almost standard today, but Remington and Weatherby also counterbore the barrel), it is nevertheless a strong and efficient design. The clean Winchester pattern seats the cartridge deeply into the barrel, with only 1/8 in. nominal protrusion, almost 1/32 in. less than in the pre-'64 pattern.

The chrome-moly receiver is patterned basically like the pre-'64 version, and like the Model 54, for that matter, with mostly only detail changes necessitated by modifications elsewhere in the action. One significant change was a slight increase in overall length to adapt the magazine area



1968 Model 70, breech

around the longest cartridges used and thus allow standardizing one receiver. Marketing factors would not permit dropping the .375 H&H chambering, and so the action was designed to this length. While there are still several part numbers for the new receiver, the differences are practically negligible from a production standpoint, in contrast to the situation with the pre-'64 receiver where machining variations in the magazine area were extensive.

This was the third change in receiver length in the history of the Model 54/70 series. The Model 54 and the pre-World War II Model 70 receivers were 8 3/4 in. long. In 1947, a new tang shape changed this to 9 1/8 in. The *new* Model 70 is 9 1/4 in. long. Magazine well length is now standard at 3.72 in., with magazine blocking used for all cartridges except the .375 H&H. The pre-'64 receivers were dimensioned around the .30-06, with a 3.50 in. long magazine well. Magazine blocking was used for shorter cartridges, while the lower locking seat was milled forward to make a 3.70 in. long magazine well for the H&H cartridges.

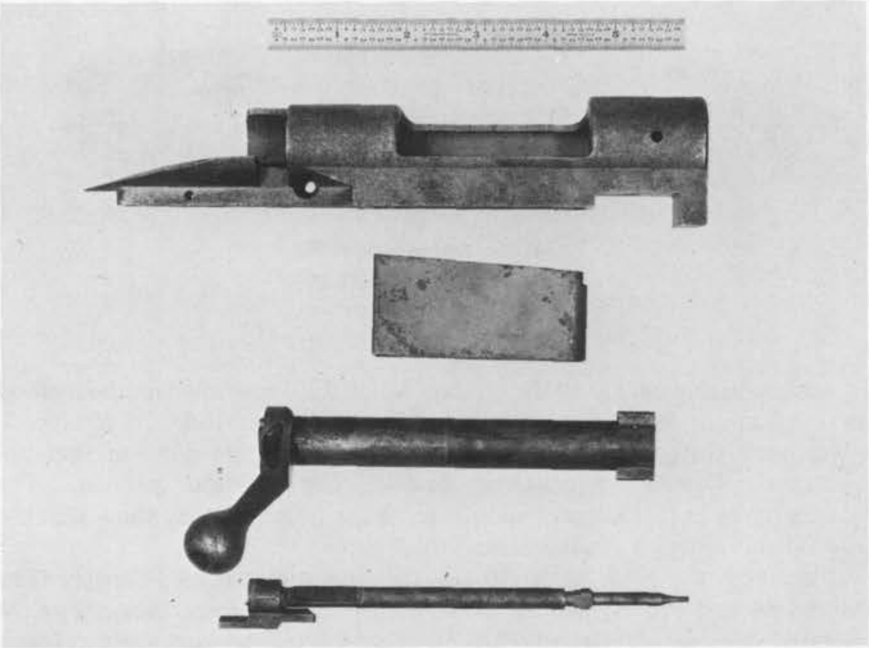
The Model 70 is no longer chambered for the .300 H&H Magnum and relatively few of the .375 H&H versions are sold anymore. Yet, from the shooter's viewpoint this change in length doesn't really turn out all bad. Those who handload ammunition get more potential room to seat bullets out properly on the so-called short magnums. Despite being about 1/2 in. longer than the original clover-leaf style Model 70, the new receiver is actually no heavier, due to its longer magazine well and lack of integral feed lips.

It would, of course, certainly have been nice if Winchester had also offered a second shorter Model 70 specially tailored for cartridges like the .308 Winchester and .222 Remington. The Model 70 is the only important centerfire bolt action made in this country that does not come in two lengths. Ever since Remington's Model 722 (if not before) a short Model 70 has been a topic of interest for many fanciers of this action. Roy Dunlap, in fact, wrote a number of articles about the techniques for cutting and rewelding Model 70s.

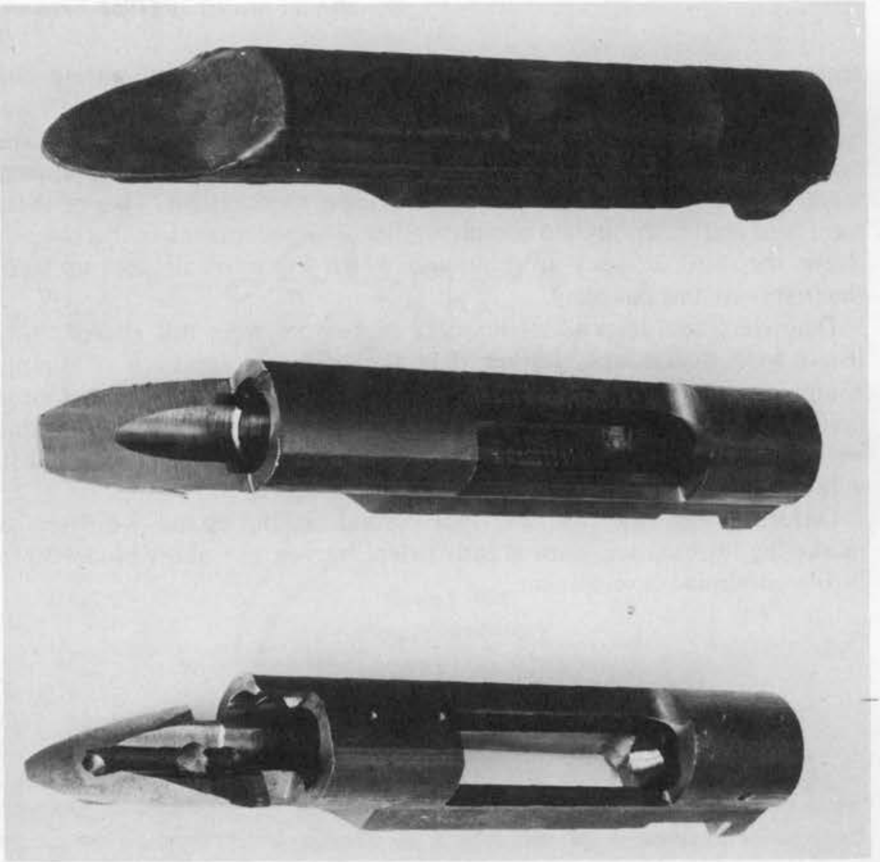
One of the first projects in the 1962–63 redesign program was the evaluation of a short Model 70. Winchester had three prototype actions made by the Mathewson Tool Co. of Orange, Connecticut. Two of these were then carried through to complete rifles. The photograph in this chapter shows the third, or back-up prototype, which was never finished up since the first two came out okay.

Diameters and thicknesses in these prototypes were not altered, only length-wise dimensions. Rather than the common approach of simply eliminating part of the midsection, the length changes were somewhat more involved. The overall length, loading/ejection port length, and magazine well length were 8.65 in., 2.60 in., and 2.97 in. respectively, compared to 9.28 in., 3.13 in., and 3.72 in. in the present Model 70.

Unfortunately, this idea never got beyond making up the two rifles, as marketing information showed insufficient interest in a short Model 70 to justify continued development.



Prototype short Model 70 developed early in the 1962-63 redesign program. Note hollow in bolt handle knob and stop-screw notch on firing pin shaft still retained at that time.



Winchester Model 70
Receiver in process

An interesting change to the receiver which did occur involves the method of fabrication. Many have concluded that the new Model 70 receiver is investment cast, because the partly unmachined underside has that appearance. Despite Winchester denials, the opinion persists. The photographs in this chapter should settle the point, as they show that the raw billet is indeed a genuine solid-forged part.

Ironically, the 1964 Model 70 was the first with a forged receiver. The Model 54 and pre-'64 Model 70 receivers were cut from barstock. Cost dictated the change. Almost 6 3/8 lb. of steel was machined away in forming the old receiver from a massive 7 1/2 lb. barstock slab. By starting with billets precision-forged close to final outside form, only 2 1/2 lb. is removed. Nevertheless, a lot of machining remains, and while the old belt-driven machine tools were replaced in the 1963 change-over, the new ones, with only one exception, are still single-operation types. This contrasts with Remington's extensive use of huge multiple-operation machine tools, or even for that matter, those used a few years ago by Winchester for the M14.

The receiver billets are forged by TRW in closed dies to exceptional accuracy. Dimensions are held within ± .010 in. The dies are constantly checked and dressed-up to hold two special locating pads on the receiver bottom within ± .002 in. of true centerline.

The receiver is first clamped against these two pads and the front faced-off square and center-drilled. This shallow hole is the temporary locating point for outside-broaching of the lower contour. The two precision-forged pads, in combination with the right half of this broached underside, then locate the receiver for subsequent operations.

What follows is a long process of single-operation machining, the work moved from machine to machine by hand. The only exception is a huge transfer-type station which drills and taps all the small holes, such as those for the guard screws and scope mounts, a total of seventeen drilling and nine tapping operations. Each receiver is clamped into a large box-like fixture with hardened and ground locating surfaces and transferred automatically from one station to the next on a chain-driven track.

Unlike most Mauser-type actions where the receiver extraction cam is simply an angle milled into the roof of the bridge, the Model 70 retains the Springfield pattern where it is actually a true helix like the chambering cams. A special machine cuts these two cam sets simultaneously to closely control their relative locations. The cams are shaved off a few thousandths of an inch at a time by front and rear single-edge cutters fixed to a common shaft and guided by a helix cam. Despite the apparent speed and the racket this reciprocating machine makes, the operation is a very gradual and precise one, taking about 1 1/2 minutes to complete.

Overall machining time on the receiver was cut by about two-thirds, yet it remains a relatively lengthy process, involving about thirty major machining operations, and with frequent inspection and gaging to assure accuracy. Any notion that the new receivers are easily or cheaply made is in error. No corners are cut or precision sacrificed in any area affecting function or appearance. Even though the sheer bulk of metal removed is greatly reduced by starting with the precision-forging, the biggest savings resulted from the elimination of fourteen hand-profile milling operations in forming the underside of the new receiver, about half of these by simplifying the magazine area, and the rest by leaving some of the underside surface in the as-forged state.

The most interesting process involves heat treatment of the receiver. Instead of the conventional approach of heating and quenching the entire part, as was done with the pre-'64 receivers, heat treatment of the new receivers is localized to the wear and strength portions only. Because the remaining portions are less effected, the overall part is less subject to warpage and distortion.

The first operation is to spot harden the extraction cam located under the receiver bridge. This is done with a powerful induction coil and the whole process of heating and quenching takes but a matter of seconds. The receivers are then racked up in sets of four and the ring portion is heat treated by a process known as austempering. This special process not only yields an excellent combination of strength and toughness, but it also avoids much of the stress and distortion associated with a normal room-temperature quench.

The ring areas are immersed in a hot salt bath. When the heating phase is completed, the receivers are immersed completely in a second medium-temperature (about 650°F) salt bath, which first quenches the ring area and then eventually tempers the entire part.

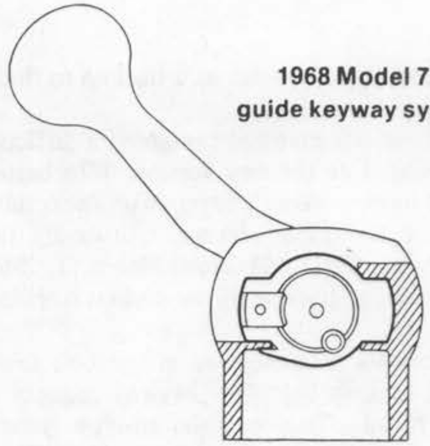
Probably more than any other single factor, the bolt accounts for the difference in appearance from the classic pre-'64 action. Not only is the hollow in the bolt knob gone, but the handle is swept back considerably less, and, because it was designed initially with a lower profile for better scope clearance, the distinctive milled section on the shank is omitted.

The bolt is made of two pieces, not three pieces as reported in some magazine articles. There is no brazed-on bolt head. The body is machined from chrome-moly steel bar, with integral locking lugs at the extreme forward end and the rear turned down and straight-knurled. The bolt handle is investment cast, with a collar at its base which is forced onto this rear section with a pneumatic press. Interference from the knurling engraves the collar, forming a sturdy mechanical joint, which is then copper-brazed.

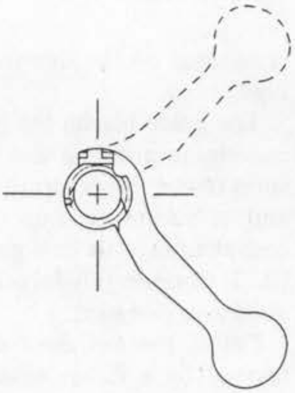
This excellent fabrication technique was developed for Winchester by the Edward Russell Co. of Wallingford, Connecticut. The process is very precise. Small copper-alloy rings are simply laid on the bolt rims. Capillary action draws these completely into the joint and no clean-up is necessary after removal from the furnace. More important, by using the high-temperature alloy (about 2000°F.) the bolt can later be heat-treated without affecting the joint. Also, the copper alloy creates a far stronger bond than possible with lower-temperature silver-brazing processes.

Although they are investment cast, the knob and part of the shank of the bolt handle are contour-turned on a special lathe and the knob then knurled. While it would seem easier to directly cast-in the knurling, as Remington does the checkering on the Model 700 bolt knobs, the Model 70 knurl pattern would require a four-quadrant die to clear the diamonds, thus leaving four parting lines.

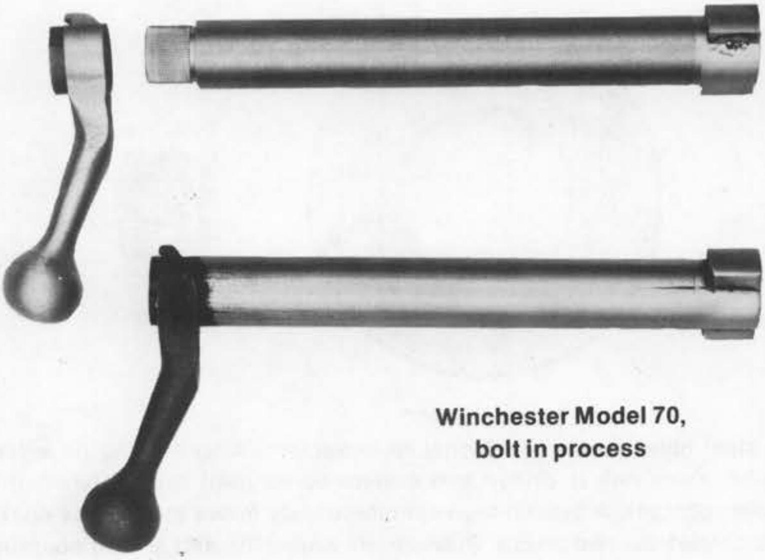
While some may regret the passing of the one-piece forged bolt, there are advantages to the new construction besides lower cost. It can be machined



1968 Model 70, guide keyway system



1968 Model 70, bolt-handle profile



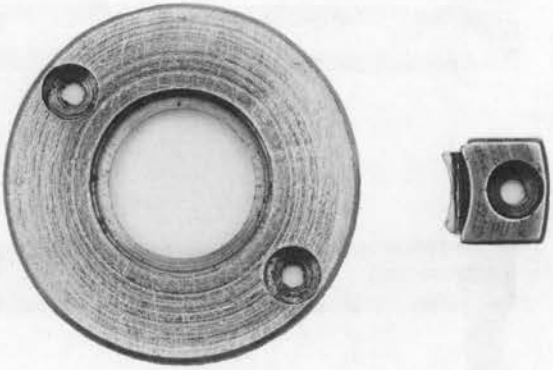
Winchester Model 70, bolt in process

to a precision not practical with the previous one-piece bolt, thus permitting a more uniform and concentric alignment of bolt, receiver, and barrel. Problems of off-center primer indentation are now practically non-existent.

Identically dimensioned locking lugs provide equal bearing in the receiver ring. The right lug, however, is carved away inside for the extractor, thus losing much of its shear strength compared to the solid left lug. The receiver is notched on the side to allow the bolt handle to act as a backup to these lugs.

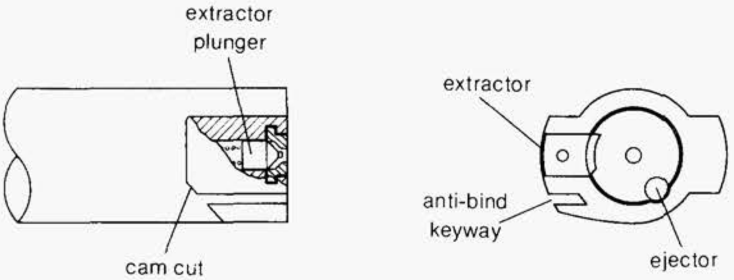
The guide lug on the pre-'64 bolt was effective but presented a difficult machining problem and was thus omitted on the new version. Winchester soon found, however, that Model 70 owners weren't happy with the results and a substitute was developed for the 1968 version. Outwardly inconspicuous, this new guide (U.S. Patent 3,431,668 issued March 11, 1969 [R. J. Creamer]) is surprisingly effective, giving one of the slickest working bolts ever designed.

Called the *anti-bind device,* it consists of a keyway in the bolt head formed by a flange under the right locking lug. This keyway engages a matching rib in the receiver to form an effective monorail-type system during the entire bolt travel, even as the bolt head passes under the ejection port. Operation is virtually jam proof, regardless of how the bolt handle is pressured or misaligned.



Each steel blank yields two Model 70 extractors. After turning on a screw machine, each ring is drilled and counterbored (left) for the head of the extractor plunger. A broach then simultaneously forms the outside contour and separates the two pieces. Subsequent broaching and milling operations form the claw, before the final part (right) is deburred and heat treated.

The original Model 70 had the external non-rotary type extractor originally developed by Paul Mauser. It was replaced in the new Model 70 by the extractor used in the Winchester Models 88 and 100 centerfire rifles. Interestingly enough, this is basically an even earlier Mauser design (U.S. Patent 431,669 issued July 8, 1890). It comprises a small hook contained within the right locking lug. The hook is a flat steel piece sliding in a T-slot at right angles to the bolt axis and retained and tensioned by a spring-loaded plunger.



1968 Model 70, bolt head details

Because of the stresses involved, this is one small part which is not investment cast. It is sliced out of precision-machined steel rings and then heat treated. This is, of course, still much less costly than making the older design. Also, its built-in nature permits a cleaner breeching pattern, and, despite its small size, it grips about one-eighth of the cartridge rim.

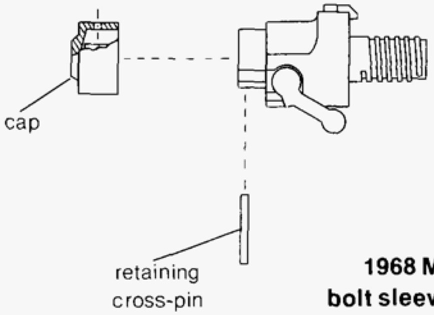
Another change made for both better breech closure and lower production costs was the adoption of a constant-tension plunger in the bolt face to eject empty cases as they clear the receiver ring.

Both the magazine and floorplate assembly follow the pre-'64 pattern. The follower is a polished stainless-steel investment casting, fully as functional and attractive as the machined versions. The main difference involves the guide lips which are now pressed into the cartridge box, rather than being machined directly into the receiver rails. This sort of change is generally looked on with disfavor by experienced riflemen, although one potential advantage is that it can simplify matters for the shooter who wants to rechamber the rifle to a substantially different cartridge.

An outwardly inconspicuous change, but one which corrects a very annoying feature of the pre-'64 version, was modification of the plunger-type floorplate catch. This little part, which for many required some form of tool to operate, was the subject of quite a bit of engineering effort during the 1962-63 period. Several new forms were developed, but, as might logically be expected, each was more expensive to make than the simple plunger. Finally, the solution adopted kept the same plunger, with its lack of purchase, but lightened the spring considerably, making for a relatively easy operation, although also of course a somewhat less positive locking action.

The gas handling system starts with the same receiver-ring port as in the pre-'64 version. This appears to be a design oversight, since without the slotted barrel, the port is half blocked off. In fact, however, it was more a matter of unconcern. Like Remington engineers, those at Winchester have difficulty finding much merit in this type of port. Thus, since the port was left in the Model 70 receiver ring primarily to avoid problems with marketing types and gun critics, repositioning it was not a matter of critical importance.

Gas entering the firing pin hole is directed to the left raceway by a single bolt-head port. The *firing pin stop screw* which had guarded against a rearward-blown firing pin is gone, replaced functionally by a shrouded bolt sleeve. Unfortunately, the shroud cap is an add-on item, merely a thin investment casting cross-pinned in place and thus neither equal to the previous stop screw nor the massive one-piece bolt-sleeve shrouds found in many other modern actions.



1968 Model 70, bolt sleeve assembly

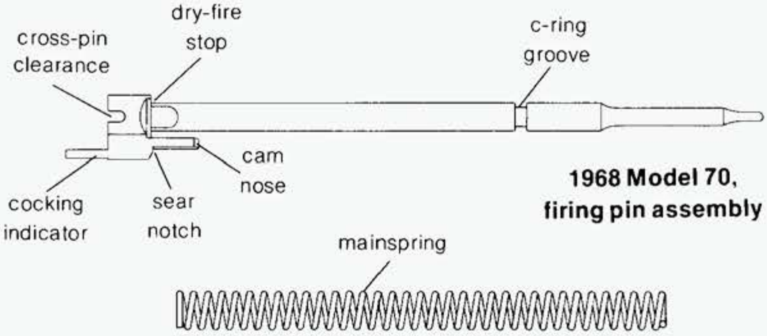
This bolt sleeve is the one area where the new Model 70 could use considerable upgrading, not only to a solid shroud, but also one with flanges to deflect away potential gas escape along the raceways. Both would involve considerable modification to other areas of the action such as the firing pin assembly, bolt stop system, and the sleeve indexing assembly. Thus, it is beyond the scope of what Winchester feels is currently necessary for the Model 70, and probably will remain so for some time to come.

The bolt stop system is basically unchanged, except it is now actuated by a torsion spring, and the length of the blocking arm on the bolt stop blade itself varies to change bolt stroke, rather than using the previous *bolt stop extension* pieces attached to the bolt head.

The firing pin assembly underwent several detail changes. At the rear, the firing pin shaft is solid, no longer notched for the stop screw. The cocking piece, an investment casting, is smaller than before. It is trimmed down and shaped to operate within the new shroud cap and has a thin flange extending back underneath as a cocking indicator. The cocking piece is still threaded, but now is locked in place by a small drive-pin rather than by heading.

Initially, the head portion of the new firing pin remained unchanged from the pre-'64 version, with the efficient, but expensive, Garand-type mainspring sleeve. In 1965, there was a change to a simple C-ring arrangement. While functionally equivalent, this was far less expensive to make than before because of the broaching and milling operations eliminated. The only problem with the C-ring was overcome in 1969 by adding a bearing cap to assure it remained concentric at all times.

This C-ring was actually adopted from the Canadian Model 70. After the *first* new Model 70 project was completed, Bob Creamer was reassigned to develop what became the Cooey Model 71, the Canadian version of the Model 70 manufactured by Winchester-Western of Ontario, Canada. While basically similar to the new Model 70, this rifle did go much further in adopting less traditional features including a cylindrical receiver and a bracket recoil lug. The C-ring mainspring sleeve was another change made very early in this rifle's development, since without existing manufacturing equipment to consider, the inefficiency of making a part like the original mainspring sleeve becomes much more obvious.



1968 Model 70, firing pin assembly

SUMMARY

Winchester periodically runs advertisements saying, in effect, "Why regret the passing of the original Model 70? The new version is an even superior firearm."

The latest Model 70 is indeed improved in most respects over the classic version. Whether it will regain the charisma of the pre-'64 rifle, however, is another question.

On a point-by-point analysis, the new Model 70 comes out on top in almost every category. The bolt and receiver are if anything stronger than before, while the receiver certainly also ends up less distorted after heat treatment. The breech is a big improvement. The two-piece bolt can be made with better precision and alignment, and bolt handle attachment is so well engineered as to eliminate it as a consideration. While smaller than before, the extractor is neat and efficient. The ejection system, likewise, is more than adequate. The anti-bind bolt is one of the fastest and slickest around.

Perhaps if any criticisms are valid they involve the fact that the receiver is bigger and heavier than needed for most of the cartridges handled. Also, the as-forged underside surfaces are not ideal for precision bedding. Finally, the bolt-sleeve cap is not only not as strong and positive as it could be, but it is not even equal to the heavy stop screw it functionally replaced.

The following summarizes the strong and weak points of the 1968 Model 70 action:

Strong points:

1. Strong and rigid receiver.
2. Adjustable override trigger.
3. Direct acting safety.
4. Smooth and positive functioning.

Weak points:

1. Action overlong for many calibers.
2. Two-piece trigger guard/floorplate assembly.

1968 WINCHESTER MODEL 70

Dimensions

OPERATING

Extraction: set-back—.15 in.
leverage—10.5 to 1

Chambering: cam-forward—.18 in.
leverage—10.5 to 1

Bolt rotation—91°

Bolt travel: .222 Remington—3.49 in.
.308 Winchester—3.84 in.
.30-06 Springfield—4.38 in.
.375 H&H—4.61 in.

Operating forces: bolt lift—8.5 lb.
bolt turndown—10.5 lb.

Cock-on-opening; .275 in.
mainspring compression
proportioned as follows:
  opening—.238 in.
  closing—.037 in.

IGNITION

Firing pin travel: at impact—.212 in.
  dry-fired—.275 in.

Lock time—3.0 ms.
Impact velocity—13.0 ft./sec.
  energy—68.1 in.-oz.
  impulse—.87 oz.-sec.

Striker/firing pin hole diameters—.077 in./.085 in.

RECEIVER

Overall length—9.28 in.

Length of loading/ejection port—3.13 in.

Ring diameter—1.340 in.

Barrel/receiver threads: designation—1-16
  engagement—.50 in. (8 threads)

Recoil lug: width—1.16 in.
  height—.43 in.
  thickness—.363 in.
  bearing area—.49 sq. in.
  clearance from magazine—1.23 in.

Guard screws: front—¼ x 32
  middle—¼x32
  rear—¼x32

Scope mounting—6x48 screws

BOLT

Lug shear area—.356 sq. in.

Lug bearing area—.073 sq. in.

Bolt diameter—.694 in.

Lug diameter—.971 in.

Bolt face: type—counterbored
depth—.120 in.

MAGAZINE

Length: .308 Winchester—2.86 in.
.30-06 Springfield—3.41 in.
.300 Winchester Magnum—3.41 in.
.375 H&H—3.64 in.

Depth: front—1.98 in.
rear—2.27 in.

Capacity: .222 Remington—5
.308 Winchester—5
.300 Winchester Magnum—3

WEIGHT

Receiver group—21.3 oz.

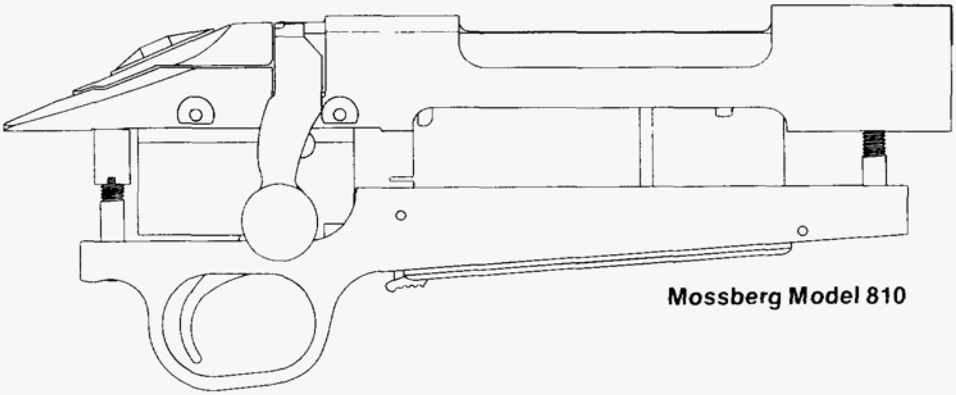
Bolt group—14.1 oz.

Magazine/floorplate group—8.9 oz.

Total action weight—44.3 oz.

16

Mossberg Model 810



Mossberg Model 810

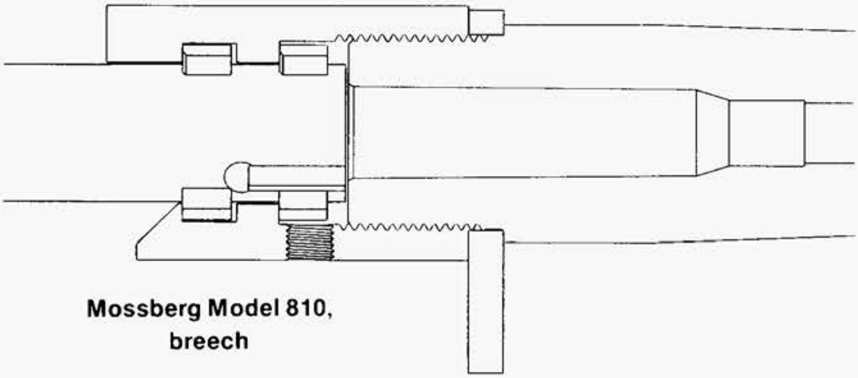
After producing the medium-length Model 800 for several years, Mossberg began work in 1968 on a larger action to complete the line. The result, designated the Model 810, was introduced in 1971.

Offering two, or even three, bolt actions to span the popular centerfire cartridges is common practice today. These are usually identical except for length, or, in the case of Weatherby and Sako, the scaling is in three dimensions, but still with a common design pattern. The 810 outwardly appears to follow this practice as a lengthened-out Model 800, but it is extensively redesigned inside.

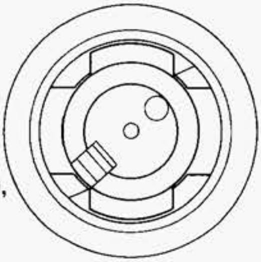
The 810 is the work of Carl Benson, and sticks much closer to Mauser principles than did the Model 800. The multiple-lug array is dropped for a full quarter-turn bolt rotation. Gone also is the full-diameter bolt. The firing pin is more conventional, with a high-suppression mainspring for smoother bolt lift. The receiver is now a simple cylinder. Finally, the trigger—while still patterned like the Model 800—is sturdier and adjustable. Thus design similarity is limited, with very few parts actually shared by the two actions.

The 810 action also became the basis for the Pedersen Model 3000, a presentation-grade rifle introduced by Mossberg in 1973. Except for a more elaborate exterior finish, the only difference is the safety. The Pederson bolt sleeve is solid on top, with the safety linkage placed to the side for a more pleasing appearance and easier operation under a low-mounted scope.

The 810 locking lugs are set back from the bolt rim slightly, giving the appearance of a Mauser or Remington pattern where a protruding bolt nose recesses into a support ring during locking. There is no recess in the 810 barrel, however, and the lug set-back was simply intended to move the front lugs off the counterbore rim for better locking rigidity.

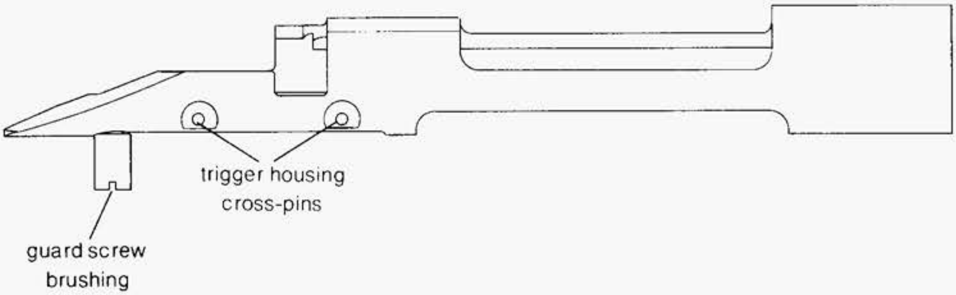


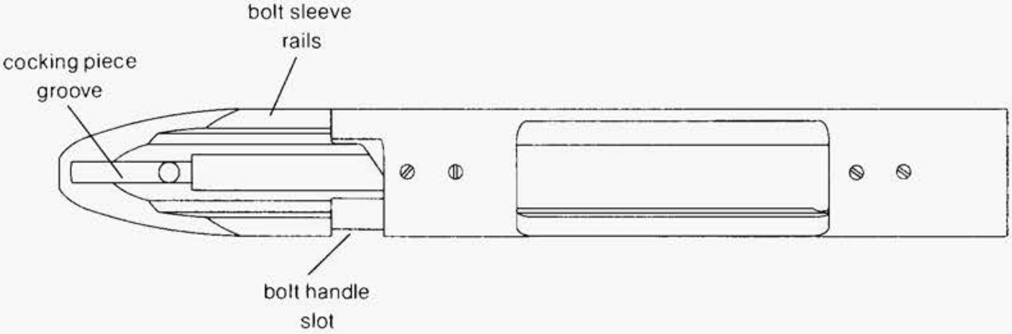
Mossberg Model 810, breech



Mossberg Model 810, front view

Mossberg buys the chrome-moly barstock from which the receivers are made already precision-ground to final outside diameter. Machining methods at Mossberg's North Haven plant are similar to those used at Winchester for the Model 70, with a series of single-operation machine



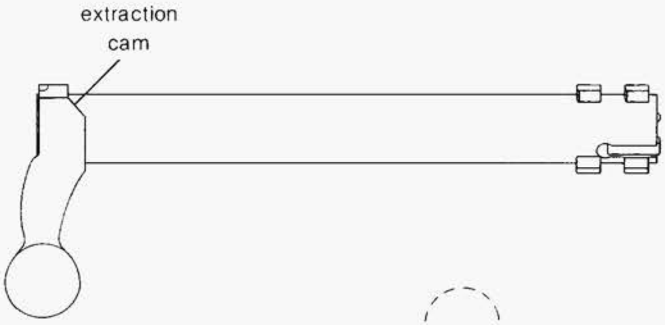


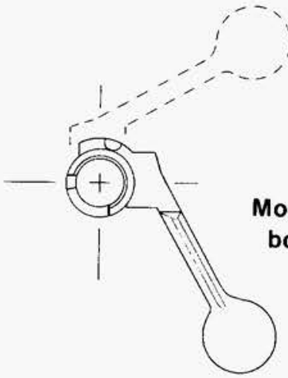
tools. Because the 810 receiver pattern is far less elaborate, however, only about twenty machines are required.

The pre-finished bars are first cut into blanks and deep-hole drilled. The trigger slot is then milled in the bottom. This slot, in conjunction with the outside diameter, locates the receiver for subsequent operations. Particularly interesting is the formation of the locking cams in the receiver ring. Mossberg built a special machine with small reciprocating filing heads guided by a tracing cam. The feed is quite rapid, the whole process taking only about thirty seconds, considerably faster than the conventional shaving technique. The very early 810s had a cam incline on each seat. Tool breakage from the simultaneous cuts led to elimination of the two front cams, and the front seats are now simply clearance-milled on a drill press, a cheaper and faster operation than cutting cam inclines.

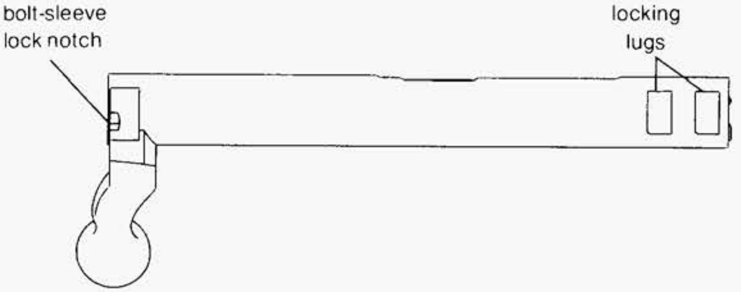
The recoil lug is a huge clamped bracket, providing almost four times the bearing surface of the Mauser M98 to avoid any possible need for a reinforcing cross bolt. Two identical guard screws are used, one under the receiver ring and the other engaging a bushing threaded into the rear tang. This bushing not only compensates for the shallow tang, but extends down far enough to permit the use of interchangeable guard screws.

Mossberg employs a more conventional diameter bolt for the 810 in order to improve magazine feed. The smaller-diameter bolt well positions the top





Mossberg Model 810, bolt-handle profile

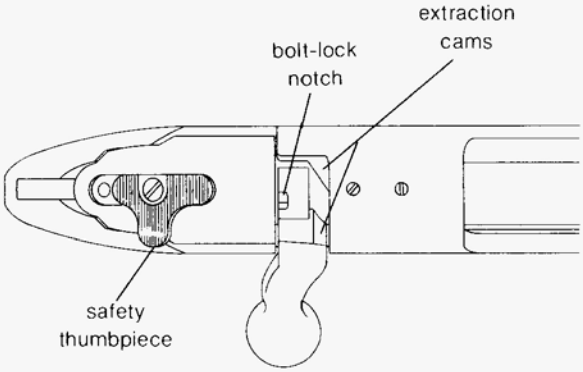


cartridge closer to the centerline of the receiver than did the Model 800, giving the bolt a better purchase in stripping it from the magazine and less rise to enter the chamber.

On the other hand, Mossberg did like the small-diameter receiver made possible by the Model 800's non-protruding locking lugs. An interesting compromise thus evolved, with a conventional bolt body, combined with shallow lugs to reduce the overall diameter of the bolt head. The Model 810 lugs are .10 in. high, compared to lug heights of .07 in. in the Model 800 and .15 in. in the Remington Model 700. The result allows a significant reduction in both the diameter of the 810 receiver and the amount of raceway broaching required.

To compensate for their lack of height, the lugs are split into a unique four-lug array, with double lugs in series for greater bearing strength. While this was not a bad idea, things were carried too far, and the 810 devotes far too much closing rotation to lug/seat engagement. An exceptionally strong locking system (.47 sq. in. shear area and .16 sq. in. bearing) and a very weak camming cycle results.

Despite a full quarter-turn bolt rotation, the cam inclines are cut so shallow that they are effective for only about 1/16 in., no better than in most multiple-lug actions. Thus, like the Weatherby Mark V, the bolt balks on closing. It must be within .06 in. of its final locked position before the cams will engage (by comparison, displacement in the Mauser M98 is .25 in., the Winchester Model 70 .18 in., and the Remington Model 700 .13 in.). Unlike the Mark V with its 56° bolt rotation, this weakness was unnecessary in the Mossberg 810.



The 810 and 800 extractors are alike except for width. Both are cut from the same drawn-steel shapes, the 800 at 1/8 in. thickness and the 810 at 5/32 in. to give about 15% more grip for handling larger cartridges.

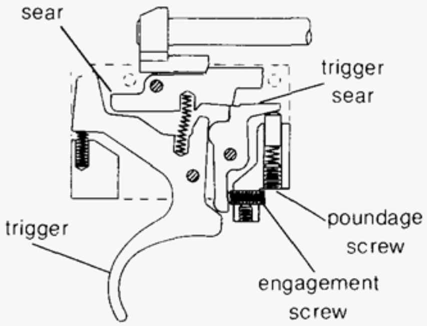
Initially, the 810 had only a detachable staggered-column magazine. In 1973, a top-loaded version was added, with the same sheet-metal construction and basic dimensions. An almost identical one-piece aluminum floorplate frame is used in both versions.

Gas handling is similar to the Model 800, with a solid receiver ring and a gas port in the bolt head. There is, however, less tendency to trap pressure in the receiver ring, since the 810 has lug raceways and no bolt shoulder. At the rear, a large turtle-shell shaped bolt sleeve blocks gas escape, both inside and outside the bolt, with a solid back and wide flanges for the raceways. In all, this is a very modern and positive system.

A tiny spring plunger locks the bolt sleeve at full lift, as in the Model 800. With the 810's conventional firing pin, however, the holding notch engagement could have served this function, eliminating the need for this special lock which simply detracts from the smoothness of bolt operation.

Use of the holding notch for this purpose is a common and effective approach. Examples are Remington, Weatherby, and Sako rifles. The fit of the 810 cocking piece could easily be adjusted to eliminate the lock plunger. While Mossberg insists it was necessary to lock the bolt sleeve positively in this way, in fact it appears more to have simply been an automatic carry over from the Model 800.

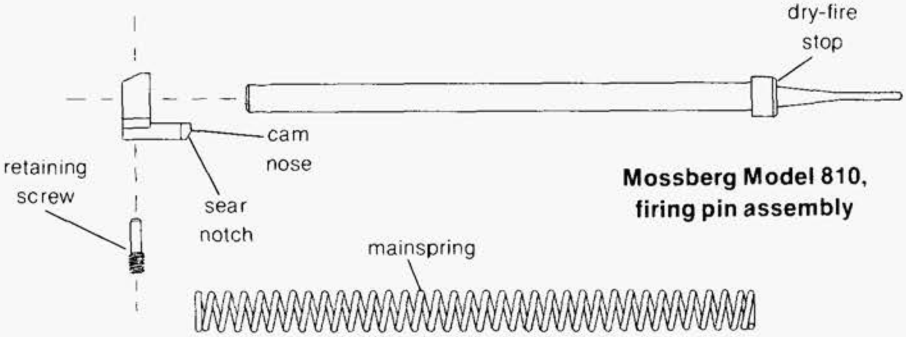
The 810 trigger is a refined and upgraded version of that in the Model 800. A heavy steel housing replaces the molded-plastic unit. The trigger is preloaded against the trigger-sear, eliminating initial slack. Finally, adjustment screws regulate poundage and engagement.



Mossberg Model 810, trigger assembly

As in the Model 800, the sear doubles as the bolt stop. It does not also form the guide means, however, since the locking lug fit is closer, providing all support during back and forth bolt travel.

The hollow firing pin in the Model 800 was interesting, but had some practical drawbacks. A more conventional pattern is used on the 810, with a long high-suppression mainspring encircling the firing pin shaft. Striker fall is shortened significantly from the Model 800. The mainspring is also more powerful, yet, because its conventional-form firing pin is heavier, lock time is not quite as fast in the 800. Also, the shorter travel results in less impact energy.



Mossberg Model 810, firing pin assembly

SUMMARY

The Model 810 is a big action, about an inch longer than the Weatherby Mark V and almost as heavy. Yet its clean lines and small receiver diameter somewhat belie its size.

Although it is improved in several respects over the Model 800—a bigger extractor, adjustable trigger, and better-proportioned and more attractive lines—operation remains somewhat rough. The following summarizes the strong and weak points of the Model 810 action:

Strong points:

1. Strong locking lugs.
2. Large recoil lug.
3. Good gas handling.

Weak points:

1. Weak camming.
2. Trigger-block safety.
3. Sear bolt stop.
4. Rough and heavy bolt operation.

MOSSBERG MODEL 810

Dimensions

OPERATING

Extraction: set-back—.07 in.
leverage—9 to 1

Chambering: cam-forward—.06 in.
leverage—12 to 1

Bolt rotation—90°

Bolt travel—4.72 in.

Operating forces: bolt lift—7 lb.
press-forward—18 lb.
bolt turndown—9.5 lb.

Cock-on-opening; .260 in.
mainspring compression
proportioned as follows:
opening—.256 in.
closing—.004 in.

IGNITION

Firing pin travel: at impact—.172 in.
dry-fired—.260 in.

Lock time—2.8 ms.

Impact velocity—12.6 ft./sec.
energy—63.7 in.-oz.
impulse—.84 oz.-sec.

Striker/firing pin hole diameters—.075 in./.079 in.

RECEIVER

Overall length—9.89 in. (10.08 in. with recoil bracket)

Length of loading/ejection port—3.25 in.

Ring diameter—1.305 in.

Barrel/receiver threads: designation—1-18
engagement—.57 in. (10 threads)

Recoil lug: width—1.30 in.
thickness—.185 in.
bearing area—.94 sq. in.
clearance from magazine—1.71 in.

Guard screws: front—¼x32
rear—¼x32

Scope mounting—6x48 screws

BOLT

Lug shear area—.466 sq. in.

Lug bearing area—.158 sq. in.

Bolt diameter—.712 in.

Lug diameter—.906 in.

Bolt face: type—counterbored
depth—.115 in.

MAGAZINE

Length—3.44 in. (3.60 in. without blocking)

Depth: front—2.02 in.
rear—2.23 in.

Capacity: .30-06 Springfield—4
7mm Remington Magnum—3

WEIGHT

Receiver group (with recoil bracket)—22.3 oz.

Bolt group—15.3 oz.

Magazine/floorplate group—9.1 oz.

Total action weight—46.7 oz.

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Conclusion

To attempt in a book like this to rate the various actions and conclude one is superior would be counterproductive. Many are not examined here. For those which are, the technical data speaks for itself, and the reader is entitled to draw his own conclusions. A useful outline of the *ideal action* is perhaps equally difficult, particularly for someone without an actual working background in firearms design. Nevertheless, the following is an attempt at practical comments on the various design aspects.

In principle, the Mauser *inner-collar* breech has yet to be improved upon. No other system strengthens both the bolt and receiver in a comparable manner. Today, the addition of a Remington-type bolt head would permit a perfectly solid collar, thus forming an extremely effective variation. Remington incidentally considered, but did not adopt, this interesting possibility when developing the 721/722 breech.

The inner-collar not only shrouds the breech and strengthens the receiver ring, it also simplifies barrel fitting. To derive this benefit, the barrel must be allowed to seat against the inner collar, thus eliminating the application of a clamped-on recoil bracket, which is really no problem, since there are better ways to take recoil anyway.

Modern receivers have more than ample strength, yet most lack the rigidity and bedding surface to derive the full potential accuracy of the barrel consistently. From a solid piece of steel, the receiver is progressively weakened as it is machined to final form. The magazine well of course removes much of the bottom surface. The loading/ejection port does the same to the top and right sides, and most are oversize for gloved operation. Another critical chunk is taken for the bolt-handle slot. Finally, the trigger, safety, and bolt-stop cut-outs usually remove much of what remains.

Accuracy demands require these cuts be minimum sized. Further, when medium to heavy barrels are considered, then more rigidity and bedding contact than possible with the conventional-sized receiver is desirable. Diameters of 1.5 in. and more are achievable with reasonable weight by using aluminum-based receivers with hardened-steel inserts.

Another limitation of present design is that the critical surfaces—guard-screw threads, locking seats, barrel threads, and receiver-ring face—are seldom perfectly aligned and true. Primarily, misalignment is introduced during heat treatment, not machining, which is extremely precise in modern production. The effect puts the barrel and action under uneven strains. Heat treatment processes specifically designed to minimize distortion, such as those used at Winchester for the new Model 70, are therefore desirable. The ideal situation is to either heat treat prior to machining or incorporate hardened inserts for bearing. Both of these approaches are expensive and now used only in limited-production actions.

Recoil lug and scope-mounting systems need attention too. A tang recoil lug forms an ideal straight-line system for maximum accuracy. It also simplifies the receiver-ring pattern. Scope attachment always seems the favorite subject for the dream rifle, and schemes ranging all the way to putting lenses into the receiver structure have been advanced. For someone with a lot of different rifles and scopes to interchange, however, special systems can be a problem. From a practical standpoint, the conventional four-screw method of scope-base attachment is more than adequate, particularly if the new larger 8x40 screws are used.

The type of bolt construction in the new Winchester Model 70 seems an ideal compromise between cost and function. The copper-brazed bolt handle grips the entire circumference of the one-piece bolt body, creating a joint of exceptional strength. It is further backed up by a rigid mechanical interference.

Concerning materials for the major parts like bolt and receiver, there is little reason to deviate from those chosen by the major arms companies in recent years. Chrome-moly steel, basically 4140 or something close to it, is almost standard in the industry today because of its combination of strength and machinability.

Carefully designed and made, a turnbolt action can operate in a smooth and positive manner without resort to special guide means. The inherent off-center forces created by the bolt-knob location, however, makes a supplemental guide system desirable. The patented configuration in the new Model 70 Winchester is a very effective and non-obtrusive example. Several similar schemes are now used to advantage by other makers. All can improve function, but should not simply substitute for precision-machined parts.

Choice of an extractor is difficult. All known types have faults. From the pure functional standpoint, the broad and massive non-rotary Mauser type is superior to all others. It also allows seating the cartridge head deep into the chamber. But it makes a mess of the bolt head.

For a neat installation, the recessed Remington C-hook is unmatched. It is also adequately positive. But it requires a deep bolt-head counterbore for purchase, and thus the cartridge head protrudes an extra distance from the chamber.

The sliding hook-type extractor invented by Paul Mauser and used in the new Winchester Model 70 is extremely compact and effective, and is compatible with a deep-seated cartridge. Unfortunately, it requires flush locking lugs, and thus cannot be adapted to a shrouded breech.

The best compromise appears to be Mauser's flush cylinder-mounted hook, as now used in Weatherby, Sako, and Steyr-Mannlicher rifles. The angles and resiliency should allow easy engagement without hesitation during closing, and yet a positive grip, preferably over at least one-eighth of the cartridge rim. It should be carefully dimensioned so that the cartridge head can be seated to within 1/8 inch of the chamber mouth, and finally support by the bolt and receiver collar should preclude any possibility of blow-out from gas leakage.

The conventional magazine eliminates much of the receiver's potential rigidity and bedding surface. Best accuracy from any design is obtained with a solid-bottomed version, but single-shot bolt actions have limited application.

In a magazine version, the single-column type is relatively trim, leaving a good deal of the receiver's underside intact. However, they are deeper than a staggered-column type unless capacity is sacrificed. Capacity of a flush configuration is normally limited to four in .222 Remington, three in .308 Winchester, and two in the belted magnums.

The more common staggered-column system adds at least one cartridge to each of the above, within a comparable depth. Magazine width, however, increases about 50%, thus removing a good deal more receiver structure.

Since the magazine opening is not a machining reference, it is certainly feasible to offer a line of rifles with a choice between magazine and solid-bottom receivers or, for that matter, even a choice of magazine types.

Cartridge-feed lips were directly machined into the classic pre-war receivers, obviously a very rugged and functional approach. About the only thing that can be said for the new system of pressing them into the cartridge box is that rebarreling to a new cartridge is sometimes simplified. Nevertheless, considering the machining costs involved, it is difficult today to justify any other approach.

The locking and camming phases are interwoven, and strength must be carefully balanced against smooth function. A full quarter-turn bolt rotation best achieves this goal, and the lugs on an action like the Remington Model 700 have about an ideal combination of strength and positive operation. Camming is more than adequate, and with shear and bearing areas of about .4 and .1 sq. in. respectively, and being of properly heat-treated alloy steel, their strength greatly exceeds that necessary for any sporting cartridge.

Actions like the Weatherby Mark V or Remington Model 788, with short-lift multiple-lug bolts, lack operating ease. Other unusual patterns, such as those of the M1917 Enfield or Mossberg Model 810, while not objectionable, offer little practical advantage either.

Mauser placed his locking lugs in the receiver ring, and this has remained more or less a standard for good reason. Despite a recent upsurge in rear locking designs, the more rigid front-locked action remains superior for application to the centerfire cartridge.

The bolt action is inherently prone to gas leakage. Modern actions of other types—the M14 and Winchester Model 88 as examples—are often far superior because the rear of the receiver forms a natural protective shroud. Nevertheless, careful design can achieve an acceptable gas-handling system in the bolt action.

The collar-type breech controls gas-release at its source. Further blocking which traps pressure within the receiver-ring interior is not advisable since this is not the ideal place to create high pressures. At the back, the bolt sleeve should flange the rear of the bridge to divert gas leakage between the bolt and receiver.

A small firing pin hole, such as in the Remington Model 788, is by far the best means to limit pressure within the bolt. Bolt-cylinder ports, such as in the Weatherby Mark V, are also helpful. A sturdy bolt sleeve shroud capping the rear of the bolt is an important item, as it stops both pressure and a rearward-driven firing pin.

Many recent designs have overlooked the full camming potential of the turning bolt, failing to achieve the strength and positive function inherent in the basic Mauser system. Staple designs like the Winchester Model 70 and Remington Model 700 fortunately retain good cam balance.

To assure smooth and positive operation under all conditions, extraction and chambering cam displacements of at least 1/8 inch are desirable, with leverages around 10 to 1. The cocking cam should be deep enough to reset the lock during lift (cock-on-opening), yet leave enough mainspring compression for closing to give a well-balanced and efficient operating cycle. The actual camming surfaces should be large, smoothly finished, and of course, properly hardened.

While the Mauser-type direct safety is positive, often ease and silence of operation are not good. The Remington and Canjar type, camming directly on the sear, is essentially as positive, and at the same time easier to operate and less subject to tolerances within the action. Thus, all things considered, it represents the best system yet developed.

The spring-loaded plunger ejector has minor faults, but its trimness and compatibility with a clean breech closure almost dictate its use. By regulating spring tension, it can be satisfactorily tailored to any particular requirement.

Many good bolt stop systems exist. Those in both the Remington Model 700 and Winchester Model 70 are unobtrusive and efficient. To keep the bottom of the receiver clean for maximum bedding, however, a small push-button unit in the left raceway wall is better.

An almost unlimited variety of effective firing pin patterns are possible. Both the Mauser rod-type and the Arisaka piston-type offer many interesting solutions. Thus, there appears no advantage in working up a specific configuration here, and instead the following outlines the process of roughing out the design parameters. The equations and figures referred to below are from the *Lock Time* section of the Appendix.

Some basic parameters are first assumed. Needed striker energy (E) is assumed as 80 in.-oz. (5 in.-lb.) and average (with distance) mainspring compression ($\bar{f}$) as 20 lb. This latter figure is chosen to assure smooth bolt operation. While many recent bolt designs exceed this, it is unnecessary, as these calculations will indicate. One of the outstanding potentials of the bolt action rifle is smooth and easy functioning, and keeping mainspring forces down to a reasonable level, along with retention of a full quarter-turn bolt lift, helps achieve this.

Using the preceding assumptions, necessary firing pin fall (S) can be computed:

$$E = f \times S \qquad S = \frac{5 \text{ in.-lb.}}{20 \text{ lb.}} = .25 \text{ in.}$$

Assuming a soft mainspring rate (K) of 8 lb./in. (which again helps guarantee smooth operation), the initial and final mainspring loads (Fo and F) can be established:

$$F_o - F = K \times S = 8 \text{ lb./in.} \times .25 \text{ in.} = 2 \text{ lb.} \qquad \begin{aligned} F_o &= 21 \text{ lb.} \\ F &= 19 \text{ lb.} \end{aligned}$$

From Figure 3, the required wire size is found to be approximately .052 in.

In order to get the most from the 80 in.-oz. impact, a high-velocity (V) striker blow is desirable. Assuming 20 ft./sec., the approximate firing pin weight can be computed:

$$E = 1/2MV^2 \qquad 5/12 \text{ ft.-lb.} = 1/2M(20 \text{ ft./sec.})^2$$

$$M = .0021 \text{ lb.-sec.}^2/\text{ft.} \qquad (1.1 \text{ oz.})$$

The approximate lock time (T) which the above parameters will yield can be quickly determined using Figure 3:

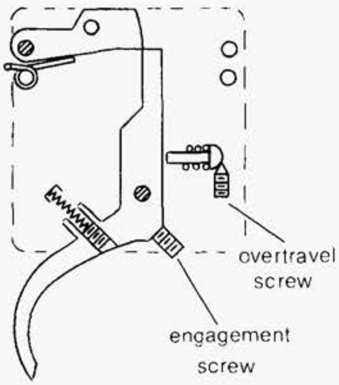
$$\text{For} \qquad K = 8 \text{ lb./in.}, \qquad Fo = 21 \text{ lb.} \quad : \quad T/\sqrt{M} = .045$$

$$\text{Since:} \qquad \sqrt{M} = \sqrt{.0021} = .045 \qquad T = .045 \times .045 = .002 \text{ sec.}$$

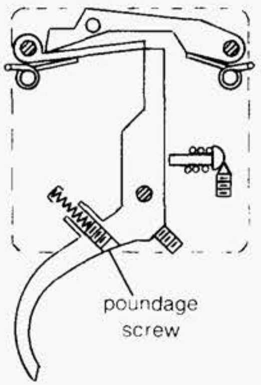
A trial and error process would now follow to fit these desired parameters within a practical envelope compatible with the rest of the action.

An ideal trigger system would offer both two-lever and three-lever versions to suit the rifle's intended application; the two-lever for general use and the three-lever for target work. The first should be capable of positive functioning down to about 3 lb. and the second about 1/2 lb.

A good trigger unit requires both proper design and rigid and carefully made materials. It should be fully adjustable, with adjustments accessible from underneath (i.e. with the bolt in place to permit rapid and precise tuning) and without removing the stock. The preceding is a big order, but readily possible with techniques already in use. The following sketches show how the above could be accomplished with a single basic pattern.



Two lever trigger



Three lever trigger

Popular centerfire cartridges fall into at least four basic lengths. An ideally proportioned bolt-action line might, therefore, likewise incorporate four lengths, if not completely scaled actions. There could be some argument about full scaling, since, as shown in the Appendix, cartridge length and head size are not necessarily proportional. Also, full-scaling is hardly practical. Sako does offer three distinct actions, and the new Steyr-Mannlicher series has four lengths, but equal diameters. The more practical and common approach has two lengths, but otherwise identical actions. Examples include the Remington Model 700, Savage 110, BSA Monarch, Texas Magnum/Maverick, and Ruger Model 77. A few makers stick to one size, best known being the Winchester Model 70 and F. N. Supreme.

Optimum weight and size is a subjective matter. From a pure strength consideration, an adequate bolt action can be quite light and trim. Heavy and bulky configurations legitimately evolve only to achieve better accuracy, by a more solid and rigid interface with the stock and barrel. In a general-purpose hunting rifle, light weight must dominate, and overall weights not exceeding 36 and 40 oz. are desirable goals for short and long version actions.

There are three major sub-assemblies: The receiver group, bolt group, and magazine/floorplate group. Internal proportioning between these is a significant and controllable engineering factor.

The conventional *Mauser* action has a .7 in. diameter bolt. This is more than adequate for all common centerfire cartridges, including those with .532 in. belts. The *full-diameter* bolt, as popularized by Weatherby, generally runs .8 to .85 in.

While there are merits in the full-diameter bolt concept, such bolts are heavy. Remington Model 700 and Winchester Model 70 bolts weigh 13.6 and 14.1 oz. respectively. Bolts in the Weatherby Mark V and Texas Magnum weigh 18.1 and 16.6 oz. Thus, several ounces are unavailable for use elsewhere.

In the magazine/floorplate group excessive bulk obviously serves even less purpose. Early bolt actions put a lot of metal here. The Mauser M98 and Springfield M1903 units weighed around 11 oz. A few modern assemblies have somehow managed to even exceed this. In comparison, the assembly in the BDL grade Remington Model 700 weighs less than 6 oz. Since it functions nicely, there is little need for heavier parts.

This leaves the receiver, one place where extra metal can be very useful in the right places. Conventionally, diameters—or equivalent cross-sections—run between 1.3 and 1.4 in. For strength during firing, thick receiver-ring walls are desirable. For solid barrel support, the section between the guard screws should also be heavy and of rigid cross-section. To bed strongly into the stock, adequate underside surface is needed, achieved by both increasing overall dimensions, and minimizing or eliminating cuts for the magazine, trigger, safety, and bolt stop.

The following comparison specifically examines this aspect and the variances which can exist by breaking the total weight (in oz.) of three actions into each group.

	Springfield M1903	Remington 700 (ADL grade)	Weatherby Mark V
Receiver group	17.8	19.2	20.8
Bolt group	16.0	13.6	18.1
Magazine/floorplate group	10.5	5.3	11.6
Total action weight	44.3	38.1	50.5

While the Model 700 is considerably the lighter, receiver weight is comparable. Further, if Remington chose to allow as much overall weight as the Weatherby Mark V, a massive 2 lb. receiver could be used, giving an overwhelming accuracy advantage over almost any conventional action. Thus analysis recommends a proportioning like that in the Remington Model 700 series, allowing a substantial receiver structure combined with trim overall weight.

Appendix

LOCK TIME

Of the total elapsed time required to fire a cartridge, that which is attributable to the rifle and ammunition involves three distinct intervals; trigger actuation to sear release, sear release to striker impact, and striker impact to exit of the bullet from the muzzle. The first two are combined under the term *lock time* and the third is termed *action time* (although, again it is really a combination, this time of ignition/barrel times).

Lock time is a pure mechanical function. Action time involves the ammunition and barrel. Typically, it runs 1 to 1.5 ms., while lock time in a bolt action runs between 2 and 9 ms. For non-straight-line systems such as found in levers, pumps, and automatics, lock time can be even considerably greater.

Since lock time is the larger interval, and that controlled by the action's design, it is the item of interest here. It is primarily a function of the length of firing pin travel, the power of the mainspring, and the weight the mainspring must accelerate.

Friction within the firing pin assembly and the effect of the trigger system are also factors. The contribution of the trigger varies with its type. This aspect is considered separately at the end of this section, but suffice to say that it would not be at all practical to attempt its inclusion in the calculations which follow. To attempt to factor in friction would likewise preclude manageable calculations and measurements. Fortunately, the error from neglecting friction is relatively minor in the straight-line lock mechanisms found in bolt actions. To offset what effect there is, firing pin travel to full protrusion, rather than to primer impact, is used in the calculations.

By neglecting the trigger and friction effects, calculation of lock time becomes a remarkably simple procedure. Only mainspring rate, initial and final mainspring compression, and the weight of the moving parts in the firing pin assembly are needed. Each is easily measured.

Notations

A = acceleration
E = striker impact energy (in.-lb. = 16 in.-oz.)
f = mainspring force
Fo = initial mainspring load (lb.) = XoK
F = final mainspring load (lb.) = XK
K = mainspring rate (lb./ft. = 12 lb./in.)
M = mass of accelerated parts—firing pin assembly plus one-third mass of the mainspring (lb.-sec.^{2}/ft.)
S = distance traveled
T = lock time (sec. = 1000 ms.)
V = velocity
x = mainspring compression
Xo = initial mainspring compression from free length (in.)
X = final mainspring compression from free length (in.)

Calculation

If the driving force of the mainspring is assumed to be constant (which it is *not*) the following lock-time formula is easily derived from Newton's Second Law (force = mass x acceleration) by the use of Integral Calculus:

$$f = MA = M\frac{d^2S}{dT^2} \qquad A = \frac{f}{M} = \frac{d^2S}{dT^2}$$

$$V = \int_0^T A\,dT = \int_0^T \frac{d^2S}{dT^2}\,dT = Vo + AT$$

$$S = \int_0^T V\,dT = \int_0^T (Vo + AT)\,dT = \int_0^T \left(Vo + \frac{d^2S}{dT^2}T\right)dT = VoT + 1/2AT^2$$

since $A = \frac{f}{M}$ and $Vo = 0;$ $\qquad S = 1/2(f/M)T^2$

solving for T: $\qquad T = \sqrt{\frac{2SM}{f}}$

This very simple formula appeared in gun books and magazines some years ago. Its solution requires that we know the average value of mainspring thrust (f) as a function of time. Since mainspring compression won't be linear with time, a simple arithmetic average can yield only a good approximation, not an exact answer.

To develop a more useful solution, the relation between mainspring driving force and the position of the firing pin (f = - xK) is combined with Newton's Second Law (f □ MA), yielding the following:

$$- xK = MA = M\frac{d^2x}{dT^2} \qquad\qquad - \frac{xK}{M} = \frac{d^2x}{dT^2}$$

Rigorous solution of the above is a rather involved procedure, requiring the technique of Differential Equations. It is found in most Mechanical Vibrations texts and yields the following:

$$X = Xo \cos T\sqrt{\frac{K}{M}}$$

Solving for T:

$$T = \frac{\cos^{-1}(X/Xo)}{\sqrt{K}}\sqrt{M} \qquad \text{(Equation 1)}$$

Before demonstrating the application of Equation 1, a few comments on analytical versus empirical techniques are appropriate. You can *calculate* what the performance of a lock mechanism should be, while you can *measure* only what it actually is. In other words, calculation can precisely define design potential. Direct measurement may yield a misleading value due to a production fault in the particular action tested, such as rough or misaligned guides, a slightly bent firing pin, or excessively tight clearances. The same applies to problems with the critical and expensive high-speed measuring apparatus. The parameters in Equation 1 are not similarly affected, and are readily determined with precision.

Taken together, both approaches contribute to a complete analysis. The analytical approach is the more useful here, as it permits an insight into the ingredients of lock performance. To validate the application of Equation 1 to centerfire rifles, laboratory lock-time measurements were obtained. This data confirmed a good practical correlation between measured and computed values.

The following examples demonstrate the application of Equation 1. These cover extremes of design; the Springfield with one of the slowest locks of a bolt action still in popular use today, the Model 54 which pioneered a fast-lock approach back in the 1930s, and Model 788 which is a good example of modern low-weight, high-velocity systems.

Springfield M1903
$X_o = 2.952$ in.
$X = 2.342$ in.
$K = 4.17$ lb./in.
$M = 3.5$ oz. $= .0068$ lb.-sec.^{2}/ft.

$$T = \frac{\cos^{-1}(2.342/2.952)}{\sqrt{12 \times 4.17}} \sqrt{.0068} = .093 \times .082 = .0076 \text{ sec.}$$

Winchester Model 54
Speed Lock
$X_o = 3.110$ in.
$X = 2.855$ in.
$K = 7.06$ lb./in.
$M = 2.5$ oz. $= .0048$ lb.-sec.^{2}/ft.

$$T = \frac{\cos^{-1}(2.855/3.110)}{\sqrt{12 \times 7.06}} \sqrt{.0048} = .044 \times .069 = .0031 \text{ sec.}$$

Remington Model 788
$X_o = 3.600$ in.
$X = 3.297$ in.
$K = 4.81$ lb./in.
$M = .92$ oz. $= .0018$ lb.-sec.^{2}/ft.

$$T = \frac{\cos^{-1}(3.297/3.600)}{\sqrt{12 \times 4.81}} \sqrt{.0018} = .054 \times .042 = .0023 \text{ sec.}$$

Design

This section considers lock design, not simply the examination of existing configurations. There are basically three ways to improve lock time, as listed below. (Reducing friction by improving guiding and lubrication and smoothing up parts represents a fourth way. Our mathematical approach, however, neglects friction as noted earlier.)

1. Increase mainspring force/shorten striker fall.
2. Lighten the firing pin assembly.
3. Decrease required striker energy.

Increasing mainspring load/shortening fall:

This first item comprises two separate factors, each affecting striker energy. To proceed in a logical manner, they can be tied together by a fixed striker energy. It will be assumed that lock time is decreased by a combination of increased driving force/decreased fall which holds impact velocity, and thus energy, constant.

Equation 1 is useful only in computing the performance of an existing lock mechanism and will have to be rearranged to incorporate only primary inputs. First, the mass or inertia factor is factored from the right side, since it is treated separately later. The remaining expression defines only mainspring behavior.

$$\frac{T}{\sqrt{M}} = \frac{\cos^{-1}(X/Xo)}{\sqrt{K}} \qquad \text{(Equation 2)}$$

Since mainspring driving force is a direct and linear function of compression, a force ratio can be substituted in Equation 2, yielding the following:

$$\frac{T}{\sqrt{M}} = \frac{\cos^{-1}(F/Fo)}{\sqrt{K}} \qquad \text{(Equation 3)}$$

Since friction is neglected, firing pin impact (kinetic) energy exactly equals the stored (potential) energy released by the mainspring during firing pin fall. Figure 1 shows this mathematical definition of impact energy (E), allowing development of an equation relating E, Fo, F, and K:

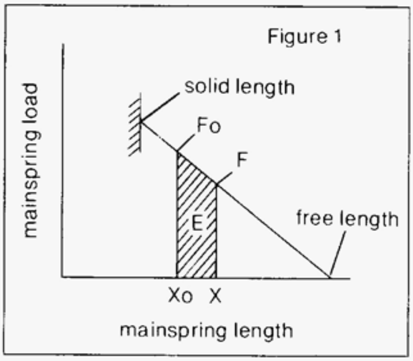
$$E = \left(\frac{Fo + F}{2}\right)\cdot(Xo - X)$$

$$E = \frac{1}{2K}(Fo + F)\cdot(Fo - F)$$

Solving for F:

$$F = \sqrt{Fo^2 - 2EK}$$

(Equation 4)



Combining Equations 3 and 4 yields a mainspring equation in terms of impact energy (E), mainspring pre-load (Fo), and mainspring rate (K), each of which is a meaningful primary input.

$$\frac{T}{\sqrt{M}} = \frac{\cos^{-1}\sqrt{1 - \frac{2EK}{Fo^2}}}{\sqrt{K}} \qquad \text{(Equation 5)}$$

The formula cannot be further modified to advantage, and Equation 5 offers a systematic means to determine optimum spring configuration. The idea is simply to get the term on the right as small as possible, while staying within practical limits on items such as size and stress levels.

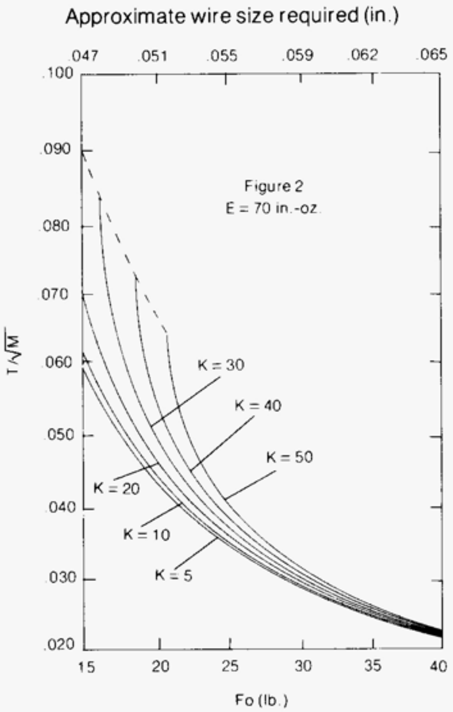
By assuming an impact energy (E), a series of curves can be generated. To limit the data plotted, only values of K between 5 and 50 lb./in., and of Fo between 15 and 40 lb. will be considered. A mainspring pre-load less than 15 lb. would require too long a firing pin fall for good lock time. And on the other extreme, levels beyond 40 lb. usually cause problems like oversize wire diameters, heavy trigger pressure, and stiff bolt operation.

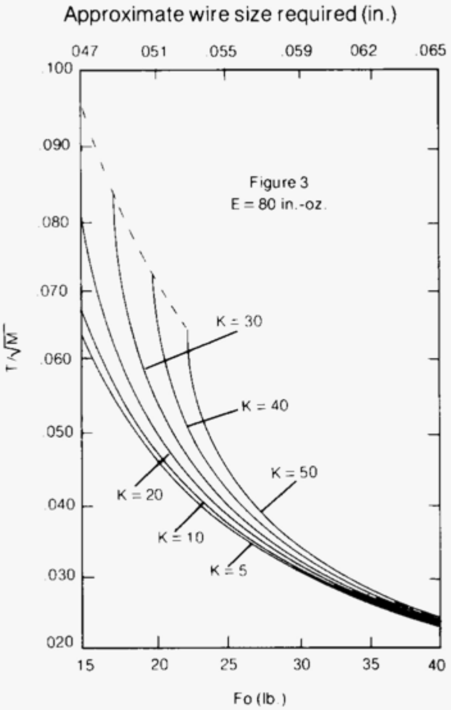
Figures 2 through 4 were generated from Equation 5, assuming impact levels of 70, 80, and 90 in.-oz. respectively. As shown in the previous chapters, this effectively spans the range found in modern bolt-action design. Also included is a rough scale of required mainspring wire size based on an allowable stress of 150,000 lb./sq. in. and assuming a typical configuration.

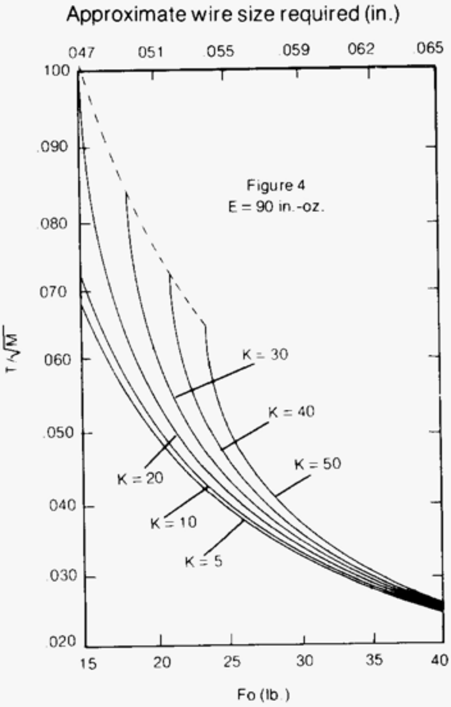
These figures show several relationships between mainspring configuration and lock time. Obviously, higher mainspring pre-loads give smaller $T/\sqrt{M}$ terms, and thus—for any given weight-lock mechanism—quicker lock times. But also, a lower spring rate gives better performance for any given pre-load, since it releases the same energy over a shorter distance. Finally, comparing the three figures, lowering the energy shifts the curves down—that is, everything else being equal, lowering energy shortens lock time.

The resulting configuration must fall within certain dimensional limits, and all points in Figures 2 through 4 are not necessarily practical. Neither is there any assurance that all combinations outside these curves are invalid, because who can prove that spring rates above 50 lb./in. or pre-loads exceeding 40 lb. are infeasible? Use of these figures was demonstrated in the Conclusion, under the section covering firing pin design.

Table 1 contains $T/\sqrt{M}$ values of a number of turnbolt actions, listed in order of *power,* with the most *powerful* listed first. These are actual measurements, not based on an arbitrarily assumed impact energy level. The lower the number, the faster the lock time, and hence the more *powerful* the mainspring setup. The term *power* as used here thus relates to the rate of energy release, not the total energy. The military actions listed near the bottom of the table actually develop relatively high impact energies, but do so slowly and so are not *powerful* as the term is used here.


Approximate wire size required (in.)
.047
.051
.055
.059
.062
.065
.100
.090
.080
.070
.060
.050
.040
.030
.020
T/√M
Figure 2
E = 70 in.-oz.
K = 30
K = 40
K = 50
K = 20
K = 10
K = 5
15
20
25
30
35
40
Fo (lb.)


Approximate wire size required (in.)
.047
.051
.055
.059
.062
.065
.100
.090
.080
.070
.060
.050
.040
.030
.020
T/√M
Figure 3
E = 80 in.-oz.
K = 30
K = 40
K = 50
K = 20
K = 10
K = 5
15
20
25
30
35
40
Fo (lb.)


Approximate wire size required (in.)
.047
.051
.055
.059
.062
.065
.100
.090
.080
.070
.060
.050
.040
.030
.020
T/√M
Figure 4
E = 90 in.-oz.
K = 30
K = 40
K = 50
K = 20
K = 10
K = 5
15
20
25
30
35
40
Fo (lb.)

While mainspring setups in modern commercial turnbolt actions widely differ physically, Table 1 shows that most end up relatively close in performance, with the $T/\sqrt{M}$ value generally falling within a range of .040 to .050. An exception is the Texas Magnum, which combines an unusually heavy mainspring with an equally short striker travel. Table 1 also shows that the older military actions generally had relatively *low-power* mainsprings, with a $T/\sqrt{M}$ term in excess of .060.

Table 1

Action	$T/\sqrt{M}$
Texas Magnum	.029
Voere Shikar	.039
Rem. M700 Short	.042
Mossberg Model 810	.043
Rem. M720	.043
Ithaca LSA-55	.043
Win. M54 Speed-Lock	.044
Rem. M721/700 Std.	.045
M1917 Numrich Kit	.045
Rem. M660	.046
Rem. M722/700 Short (pre-'68)	.047
Mossberg Model 800	.047
Win. M70 (new)	.047
Sako Vixen (L-461)	.047
M1903 Numrich Kit	.048
Savage Model 110	.048
Win. M54 Hornet S/L	.048
Weatherby Mark V	.049
Win. M70 (pre-'64)	.050
Weatherby Varmintmaster	.051
Rem. M788 (.222)	.053
Rem. M788 (.308)	.054
Win. M70 (pre-'64) Hornet	.055
Mosin-Nagant M91	.064
Mauser M98	.068
Carcano M91	.070
Rem. M30 (1930–1940)	.070
Win. M54 Plain-Lock	.071
Rem. M30 (1926–1930)	.072
Mannlicher M92	.073
Springfield M1903 (1936–1942)	.074
Springfield National Match	.074
Win. M54 30 W.C.F. Plain-Lock	.079
Springfield M1903 (1903–1936)	.079
Commission M88	.081
Arisaka Model 1905	.083
M1917/Rem. M30 (1920–1926)	.088
Springfield M1903 (1942)	.093
Mauser M91	.093
U.S. Krag M98	.096
Mauser M93	.098
Lee-Enfield Mk III	.103

Reducing accelerated mass:

This is the direct and uncomplicated way to speed lock time. The energy delivered to the primer is a function only of mainspring configuration, and is unaffected by a change in firing pin weight. Equation 1 shows that lock time varies as the square root of mass (M), so for example if mass were cut in half, lock time decreases by about one-third.

There are of course practical limits to this approach also. First, some weight comes from the mainspring itself, although this is usually almost insignificant, as only one-third appears in Equation 1. Weight of the firing pin and cocking piece thus primarily control lock time, and the firing pin must be heavy enough to withstand the stress of repeated impact and long enough to span between the bolt head and trigger. The Mossberg Model 800 and Savage Model 110 are examples of special designs which bring these points closer together, and thus reduce firing pin length and weight.

The lightest firing pin units found in centerfire bolt actions today run around 1 oz. (.002 lb.-sec.^{2}/ft.). Lightweight high-strength alloys could cut this further, but are relatively expensive. Table 2 lists *inertia factors* ($\sqrt{M}$) for the actions in Table 1, again in an order tending to contribute to fastest lock time, that is, from lightest to heaviest.

Table 2

Action	$\sqrt{M}$
Rem. M788 (.222)	.041
Rem. M788 (.308)	.042
Ithaca LSA-55	.051
Mossberg Model 800	.051
Savage Model 110	.056
Weatherby Varmintmaster	.056
Rem. M30 (1930–1940)	.058
Rem. M660	.060
Rem. M720	.061
Sako Vixen (L-461)	.062
Rem. M722/700 Short (pre-'68)	.063
Rem. M700 Short	.063
Mossberg Model 810	.064
Win. M70 (new)	.065
Voere Shikar	.065
Arisaka Model 1905	.065
Rem. M721/700 Std.	.066
Mauser M91	.067
Win. M54 Hornet S/L	.069
Win. M54 Speed-Lock	.069
Win. M70 (pre-'64)	.069
Win. M70 (pre-'64) Hornet	.070
Lee-Enfield Mk III	.071
Texas Magnum	.071
Rem. M30 (1926–1930)	.072
M1917 Numrich Kit	.073

Win. M54 30 W.C.F. Plain-Lock	.073
Win. M54 Plain-Lock	.073
M1917/Rem. M30 (1920–1926)	.073
Weatherby Mark V	.073
Springfield National Match	.074
Mauser M93	.075
M1903 Numrich Kit	.076
Mauser M98	.077
U.S. Krag M98	.081
Springfield M1903 (1942)	.082
Springfield M1903 (1903–1936)	.082
Springfield M1903 (1936–1942)	.082
Carcano M91	.091
Mosin-Nagant M91	.092
Mannlicher M92	.108
Commission M88	.110

A few observations are now possible on Tables 1 and 2. The same action does not rate highest in both. The Texas Magnum, with its *powerful* mainspring setup, has a heavy firing pin. The super-light Remington Model 788 firing pin, on the other hand, is driven by a relatively *weak* mainspring. Nevertheless, both combine for very quick lock time—about 2 ms. If their features were favorably combined in a single design, lock time could approach a 1 ms. level.

Table 3 summarizes the performance of the actions covered in Tables 1 and 2, with lock time the product of the mainspring factor (from Table 1) times the inertia factor (from Table 2). Listing is in the order of lock time, with the fastest first. Also given are the conditions at primer impact and those existing at the completion of primer indentation. Since the bolt action lock mechanism is far from a pure inertia system (such as the dropped-ball devices used to establish primer sensitivity), there can be a significant difference between these, particularly in bolt actions with heavy mainsprings and short falls where a significant portion of energy is delivered to the primer after initial impact.

Decreasing required striker energy:

There is a correlation between striker energy and lock time. For any given mainspring, if striker energy can be decreased, so can striker fall, and thus lock time.

But how is this done without jeopardising ignition? It might seem logical to assume that given a proper striker-point diameter, shape, and protrusion, that only impact energy remains as a significant parameter establishing the primer's reaction to the firing pin blow. The impulse or momentum of the striker blow, however, also affects its nature.

Appendix

Table 3

Action	Lock time (ms.)	Primer Impact				Primer indentation (.025 in.)	
		Striker fall (in.)	Velocity (ft./sec.)	Energy (in.-oz.)	Impulse (oz.-sec.)	Striker fall (in.)	Energy (in.-oz.)
Texas Magnum	2.0	.124	12.3	72.8	.99	.149	86.6
Rem. M788 (.222)	2.2	.249	20.9	71.0	.57	.274	77.9
Ithaca LSA-55	2.2	.209	17.0	72.4	.71	.234	79.9
Rem. M788 (.308)	2.3	.249	19.7	66.5	.56	.274	72.9
Mossberg Model 800	2.4	.240	17.5	77.4	.74	.265	82.9
Voere Shikar	2.5	.185	13.6	74.2	.91	.210	83.5
Rem. M720	2.6	.183	13.6	65.0	.80	.208	73.4
Rem. M700 Short	2.6	.213	15.2	87.2	.96	.238	97.0
Savage Model 110	2.7	.295	19.6	116.7	.99	.320	125.8
Rem. M660	2.8	.228	14.9	77.3	.86	.253	85.1
Mossberg Model 810	2.8	.172	12.6	63.7	.84	.197	72.5
Weatherby Varmintmaster	2.9	.239	15.2	70.7	.78	.264	77.6
Sako Vixen (L-461)	2.9	.210	13.4	66.5	.83	.235	73.6
Rem. M721/700 Std.	3.0	.213	13.7	79.7	.97	.238	88.3
Rem. M722/700 Short (pre-'68)	3.0	.213	13.4	67.9	.84	.238	75.3
Win. M70 (new)	3.0	.212	13.0	68.1	.87	.237	75.7
Win. M54 Speed-Lock	3.1	.205	12.3	69.7	.95	.230	77.8
M1917 Numrich Kit	3.2	.212	12.4	77.6	1.05	.237	86.5
Win. M54 Hornet S/L	3.4	.205	11.3	58.5	.87	.230	65.4
Win. M70 (pre-'64)	3.5	.261	13.6	86.1	1.05	.286	94.0
Weatherby Mark V	3.6	.237	12.4	78.9	1.06	.262	86.7
M1903 Numrich Kit	3.6	.224	11.6	73.4	1.06	.249	81.1
Win. M70 (pre-'64) Hornet	3.8	.261	12.6	74.8	.99	.286	81.6
Rem. M30 (1930–1940)	4.1	.389	17.0	94.8	.93	.414	100.5
Rem. M30 (1926–1930)	5.2	.396	13.3	88.4	1.10	.421	93.5
Win. M54 Plain-Lock	5.2	.411	14.2	102.5	1.20	.436	108.1
Mauser M98	5.2	.468	15.1	130.2	1.44	.493	136.4
Arisaka Model 1905	5.4	.494	15.4	96.5	1.05	.519	100.3
Springfield National Match	5.5	.546	16.8	149.7	1.48	.571	155.8
Win. M54 30 W.C.F. Plain-Lock	5.7	.411	12.8	83.0	1.08	.436	87.5
Mosin-Nagant M91	5.9	.433	12.9	132.9	1.72	.458	139.5
Springfield M1903 (1936–1942)	6.1	.546	15.2	149.7	1.64	.571	155.8
Mauser M91	6.2	.975	24.8	264.8	1.78	1.000	269.4
Carcano M91	6.4	.480	13.0	135.8	1.74	.505	142.3
M1917/Rem. M30 (1920–1926)	6.5	.647	16.8	145.5	1.44	.671	150.4
Springfield M1903 (1903–1936)	6.5	.546	14.3	133.1	1.55	.571	138.5
Lee-Enfield Mk. III	7.3	.719	15.6	116.1	1.24	.744	118.9
Mauser M93	7.4	.967	20.7	231.3	1.86	.992	235.4
Springfield M1903 (1942)	7.6	.546	12.2	97.5	1.33	.571	101.5
U.S. Krag M98	7.8	.518	11.3	81.8	1.20	.543	85.3
Mannlicher M92	7.9	.527	11.4	143.4	2.10	.552	149.1
Commission M88	9.0	.530	10.0	116.5	1.94	.555	121.2

Both striker energy ($1/2MV^2$) and impulse (MV) are functions of the mass and velocity of the firing pin, but with velocity more important in the energy term since it appears to the second power. If a firing pin is lightened, velocity will increase exactly enough to hold the energy term constant. Since impulse is only to the first power of velocity, however, it diminishes. Conversely, if the same impact energy is achieved with a heavier and slower-moving firing pin, a higher impulse effect results.

It might intuitively seem that impulse improves the detonation effect of the firing-pin blow, and thus for a given impact energy, the slower and heavier type striker blow is more effective. It also apparently follows that the lack of momentum in a light fast firing pin fall requires an increased energy to compensate.

Both SAAMI and U.S. Army studies on the subject show that exactly the opposite is true. At a given energy level, a light firing pin giving a snappy, low-impulse blow is more effective in detonating the primer than a heavier and slower pin. A *sharp*, high-velocity impact transfers its energy to the primer faster and thus at a higher peak level. The low-velocity impact, with its greater impulse, not only transfers the energy over a longer time period, and so lower peak level, but it allows more cushioning in the energy-transfer process. This was graphically illustrated in extensive development work at Olin Corporation and described in U.S. Patent 3,056,226 of Oct. 2, 1962 (Charles Hubbard and Robert Smith).

The above explains a more subtle relationship between striker design and lock time. By only increasing mainspring power, and retaining a heavy firing pin, a low-velocity/high-impulse ignition results. By decreasing weight, the percussion becomes a high-velocity/low-impulse type. This allows designing to a somewhat lower energy, thus making possible a slight additional lock-time gain.

Another practical advantage of a light, high-velocity mechanism, is that it allows ignition with a less violent striker blow. Since the jar of the striker blow precedes the bullet to the muzzle, this enhances a rifle's potential accuracy.

Just how much impact is actually necessary for primer detonation depends also on a number of other variables. Certain standards are available, however, which consider normal manufacturing tolerances and a necessary margin for reliable ignition under varying conditions. Current U.S. Army sensitivity requirements are 48 in.-oz. for small-rifle primers and 64 in.-oz. for large-rifle primers.

Most commercial arms today use the same firing pin assembly for both primer sizes. One of the largest firearms companies bases their designs on large-rifle primer tests which established the following necessary impact levels for perfect ignition: 30 in.-oz. for a clamped primer, 40 in.-oz. for an *ideal* firearm, and 63 in.-oz. for an average production firearm. They have chosen 75 in.-oz. as the goal for their production centerfire rifles by taking the *ideal* firearm 40 in.-oz. figure and adding 10 in.-oz. for the maximum anticipated firing pin eccentricity (off-center blow), 10 in.-oz. for the maximum anticipated headspace variation (cushioned blow), and 15 in.-oz. for the effect of extreme temperatures.

Triggers

Three types of triggers are commonly applied to the bolt action, and each affects lock time quite differently. For practical purposes, the classic direct-draw type has no effect. At the other extreme, a set trigger is a miniature percussion unit in itself, creating a finite delay before the sear is even actuated, and thus in effect forming two lock mechanisms in series. The speed of set triggers varies considerably, but even the best have a 2 to 3 ms. delay. Some of the older types exceed 10 ms. This adds directly to the firing pin portion of lock time which we have been considering here with these calculations.

The basic override trigger is a sort of compromise in this respect. If we neglect elasticity within the trigger system, there is no delay of the initiation of firing pin movement. The effect of the trigger (again recalling that we are also neglecting friction) occurs during the initial phase when some mainspring power is drawn off to displace the sear. During this time, both the force of the sear spring and the inertia of the parts being overridden feed back. The sear spring is relatively weak, and the sear is small and has a short distance to travel. Accordingly, the effect on lock time is minor, no more than a fraction of a millisecond.

As more parts are added to the override circuit, as for example in the three-level Remington "2-ounce" trigger or the four-lever trigger in the Winchester Model 52C, the effect, of course, increases. Yet, because the parts all start out pre-loaded against each other, the effect is still nowhere near that of a set trigger. Measurements made at Winchester's New Haven laboratory when the four-lever Model 52C trigger was developed indicated less than a 1/2 ms. delay.

Importance

Lock time accounts for most of the delay in getting the bullet out of the rifle. The final phase, *action time*, is outside the control of the action designer and depends on factors such as primer detonation time, powder burning rate, case capacity, bullet weight, and barrel length. For practical purposes a maximum of 1.5 ms. can be assumed.

The overall delay is particularly critical when a rifle is intended for long-range or precision work. Without a perfectly steady hold, the sight picture continually changes. The shooter breaks the trigger when the sight picture looks best, and then wants the bullet out of the rifle as quickly as possible, before too much change can occur. Using two extreme examples, the overall delay between trigger release and bullet exit is approximately 3.5 ms. in the Texas Magnum and 9.1 ms. in the Springfield M1903. In the time it takes the Springfield firing pin to reach the primer, the bullet from the Texas Magnum is already out of the barrel and several yards downrange.

SPEED LOCKS

Lock times in early bolt actions like the Mauser M98 and Springfield M1903 generally exceeded 5 ms. In the 1930s, Winchester developed systems for the Model 54 and Model 70 giving close to a 3 ms. performance. This still represents a useful goal for current designs, with most today falling somewhere between 2 and 4 ms.

Two categories of speed locks are examined here, first efforts by Remington and Winchester between 1920 and 1940 to speed the ignition of their early centerfire bolt actions. Then, a couple of speed-lock kits were offered at very modest cost by the Numrich Arms Corporation of West Hurley, New York, for the Springfield and Enfield rifles.

All of these involve working with an existing bolt-receiver design. Length of fall was shortened by either shifting the entire firing pin forward, or simply lengthening it. Both methods create certain dimensional problems. These can include operation of the safety mechanism, overcompression of the mainspring on opening, and loss of the cocking cam as a means to prevent premature ignition. Each must be compensated for by redesign in the safety and cocking cam systems.

The lock-time figures given here for the various actions were computed using the method outlined in the *Lock Time* section of this Appendix.

Remington

Remington twice modified the ignition system of the Model 30. The lock system of the original Model 30 duplicated the M1917 Enfield. In 1926, the cocking piece was redimensioned to move the cocked firing pin .25 in. forward, reducing striker fall from .71 to .46 in. The most noticeable effect, and probably most important, of course, was to convert the rifle to cock-on-opening.

In 1930, the Model 30 was again modified, but this time without changing the length of fall. The primary change was simply to lighten the firing pin by extensive milling. Weight of the firing pin/cocking piece was reduced more than one-third.

In 1940, with the Model 720, Remington's basic line of Enfield-based bolt actions was again speed locked, this time actually resulting in a shorter striker fall (.25 in.) and lock time (2.6 ms.) than found today in the latest Model 700 series. Dimensionally, the change was accomplished primarily by extending the firing pin tip by cutting and rewelding. Accompanying modifications included a shallower cocking notch in the bolt rim to guard against accidental ignition and a repositioned dry-fire stop surface within the bolt sleeve.

Because the original Enfield system had so much striker energy, the previous Model 30 changes did not impair the reliability of ignition. By the time Remington got through with the Model 720, however, striker travel was reduced to the point where a substantially stronger mainspring was required. The early Model 720 mainsprings were heavier, but not enough so to offset the drastically shortened striker fall. The calculations here are based on the improved mainspring designed by Mike Walker when he took over the Model 720 project.

Winchester

Winchester adopted a really fast ignition system for its centerfire bolt rifles several years before Remington. The original Model 54 lock system had a slightly shorter striker fall and a headless cocking piece, but was otherwise not much different from the Springfield. Accordingly, ignition speed was only moderately improved.

In 1932, the Model 54 *Speed Lock* was introduced. The firing pin was made one piece, but this in itself did not affect lock time. The sear and cocking piece were redimensioned to effectively reposition the firing pin .25 in. farther forward at full-cock, cutting striker fall by almost one-half. To compensate, a heavier mainspring was used, the cocking notch in the bolt was made shallower, and of course the safety notch on the cocking piece moved rearward.

Numrich

Large numbers of Springfield and Enfield rifles were sold to the public over the years through the D.C.M. and other surplus sources, creating a good potential market for improvement hardware such as these Numrich speed-lock kits. Besides speeding ignition, they also eliminate the jointed firing pin in the M1903 and the cock-on-closing aspect of the M1917. Neither kit alters the bolt or receiver.

The Springfield speed-lock kit comprises four new parts: a striker, cocking piece, retaining knob, and mainspring. The cocking piece is clamped in place by a threaded knob which is flared and knurled for grasping like the issue part. A wire in the cocking piece detents into serrations in the front hub of this knob to lock it from turning. This arrangement was developed some years before by John Garand for the M2 .22 caliber rifle, and in fact the Numrich cocking piece and retaining knob are surplus Army parts.

The Numrich assembly is not significantly lighter, and thus this accounts for little of the lock-time improvement. The important change is the combination of a longer firing pin head which reduces striker travel from .61 to .29 in., and a considerably heavier mainspring.

Full-cock mainspring tension is increased from about 12 lb. to almost 22 lb. with the Numrich kit. Stiffness of bolt operation and trigger pull, however, are little affected. And on the positive side, the two-piece aspects of the Springfield firing pin are eliminated entirely, both the spongy striker blow and the potential joint failure. As a result of not using a specially designed cocking piece, however, a serious drawback of this particular modification is that the cocking notch no longer provides a safeguard against premature ignition.

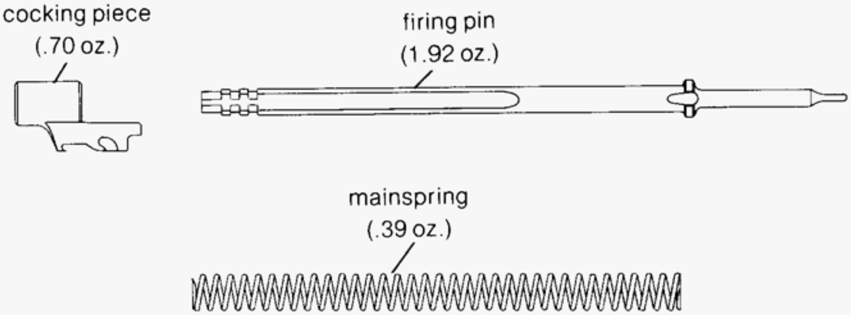
For the M1917 Enfield, the Numrich firing unit basically resembles that in the issue rifle, but with some important detail changes. An issue firing pin is supplied, accompanied by a new cocking piece and mainspring. The precision-cast cocking piece positions the firing pin farther forward at full-cock, reducing striker fall from .71 in. to .28 in.

A heavier mainspring boosts driving power by several pounds, yet bolt-lift effort remains reasonable, and in fact, overall operation is improved. Bolt lift, press-forward, and turndown forces change from 2.5, 18, and 3 lb. respectively, to a more balanced sequence of 8.5, 0, and 4.5 lb. in the Numrich setup. Also, since the Numrich assembly cocks on bolt lift, initial hesitation in pulling the bolt rearward is eliminated. Finally, the Numrich mainspring has about .4 in. more solid height, allowing less potential snap-back from a blown primer.

The new shorter striker fall requires deactivating the Enfield trigger interlock system. This is done, without altering the trigger or bolt, by making the rib under the Numrich cocking piece very shallow. As a side effect, sear engagement is reduced to the point where, despite the heavier mainspring, a lighter trigger pull results.

Enfield lock time with the Numrich kit is trimmed to 3.2 ms. Since the new assembly is about the same weight as the original, little is gained here. The significant change is the shorter striker fall, made possible, with only a moderate boost in mainspring power, by allowing a much lower energy striker blow. The original 145 in.-oz. level far exceeds that necessary, and is reduced in the Numrich setup to about 75 in.-oz., more in line with modern standards.

Issue M1917/Remington Model 30 (1920–1926)



MAINSPRING

free length—5.65 in.

coils—36 total/34 active

ends—squared and ground

wire diameter—.051 in.

outside diameter (free)—.42 in.

rate (computed)—5.9 lb./in.

INSTALLED CONDITIONS

striker fall (to full protrusion)—.71 in.

mainspring compression: at full cock—2.69 in./16.0 lb.
at full striker fall—1.98 in./11.7 lb.

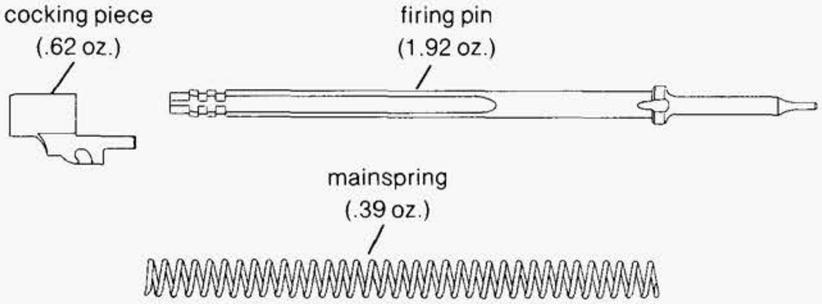
stress at full cock (Wahl corrected)—137,000 lb./sq. in.

CALCULATED PERFORMANCE

lock time—6.5 ms.

impact velocity—16.8 ft./sec.
energy—145.5 in.-oz.
impulse—1.44 oz.-sec.

Remington Model 30 (1926-1930)



MAINSPRING

free length—5.75 in.

coils—35 total/33 active

ends—squared and ground

wire diameter—.051 in.

outside diameter (free)—.42 in.

rate (computed)—5.9 lb./in.

INSTALLED CONDITIONS

striker fall (to full protrusion)—.46 in.

mainspring compression: at full cock—2.56 in./15.1 lb.
at full striker fall—2.10 in./12.4 lb.

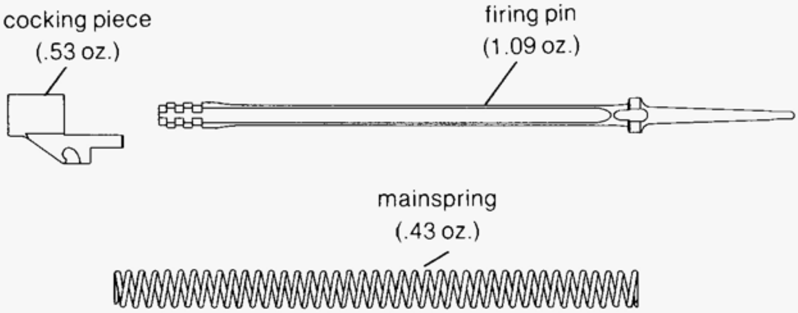
stress at full cock (Wahl corrected)—129,000 lb./sq. in.

CALCULATED PERFORMANCE

lock time—5.2 ms.

impact velocity—13.3 ft./sec.
energy—88.4 in.-oz.
impulse—1.10 oz.-sec.

Remington Model 30 (1930-1940)



MAINSPRING

free length—6.13 in.

coils—40 total/38 active

ends—squared and ground

wire diameter—.051 in.

outside diameter (free)—.42 in.

rate (computed)—5.5 lb./in.

INSTALLED CONDITIONS

striker fall (to full protrusion)—.46 in.

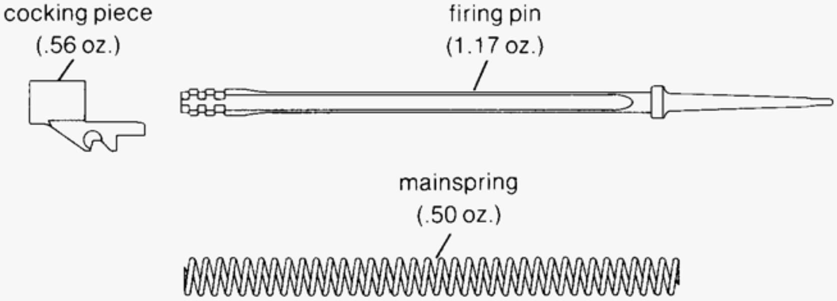
mainspring compression: at full cock—2.95 in./16.3 lb.
at full striker fall—2.49 in./13.7 lb.

stress at full cock (Wahl corrected)—136,000 lb./sq. in.

CALCULATED PERFORMANCE

lock time—4.1 ms.
impact velocity—17.0 ft./sec.
energy—94.8 in.-oz.
impulse—.93 oz.-sec.

Remington Model 720



MAINSPRING

free length—5.52 in.

coils—35 total/33 active

ends—squared and ground

wire diameter—.058 in.

outside diameter (free)—.43 in.

rate (computed)—10.1 lb./in.

INSTALLED CONDITIONS

striker fall (to full protrusion)—.25 in.

mainspring compression: at full cock—2.30 in./23.1 lb.
at full striker fall—2.05 in./20.6 lb.

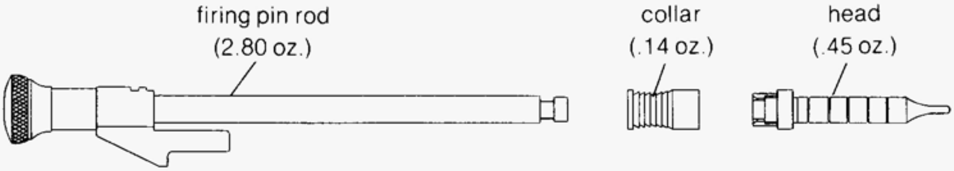
stress at full cock (Wahl corrected)—137,000 lb./sq. in.

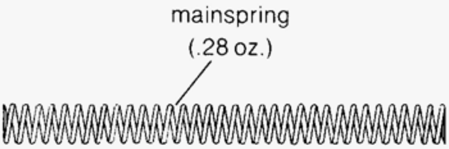
CALCULATED PERFORMANCE

lock time—2.6 ms.

impact velocity—13.6 ft./sec.
energy—65.0 in.-oz.
impulse—.80 oz.-sec.

Issue M1903


firing pin rod
(2.80 oz.)
collar
(.14 oz.)
head
(.45 oz.)


mainspring
(.28 oz.)

MAINSPRING

free length—4.78 in.

coils—35 total/33 active

ends—squared and ground

wire diameter—.045 in.

outside diameter (free)—.395 in.

rate (computed)—4.2 lb./in.

INSTALLED CONDITIONS

striker fall (to full protrusion)—.61 in.

mainspring compression: at full cock—2.95 in./12.3 lb.
at full striker fall—2.34 in./9.8 lb.

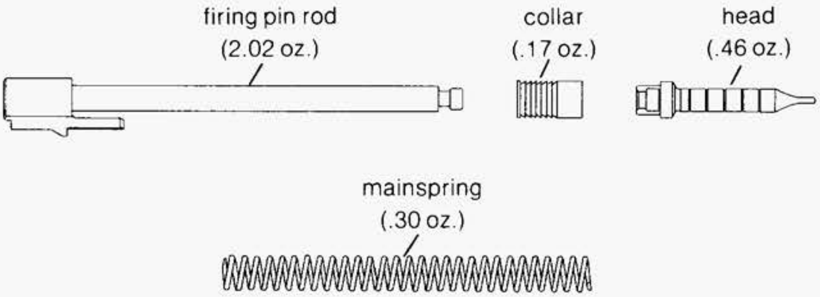
stress at full cock (Wahl corrected)—133,000 lb./sq. in.

CALCULATED PERFORMANCE

lock time—7.6 ms.

impact velocity—12.2 ft./sec.
energy—97.5 in.-oz.
impulse—1.33 oz.-sec.

Winchester Model 54 Plain Lock


firing pin rod
(2.02 oz.)
collar
(.17 oz.)
head
(.46 oz.)
mainspring
(.30 oz.)

MAINSPRING

free length—4.62 in.

coils—32 total/31 active

ends—ground

wire diameter—.051 in.

outside diameter (free)—.40 in.

rate (computed)—7.1 lb./in.

INSTALLED CONDITIONS

striker fall (to full protrusion)—.50 in.

mainspring compression: at full cock—2.41 in./17.0 lb.
at full striker fall—1.91 in./13.5 lb.

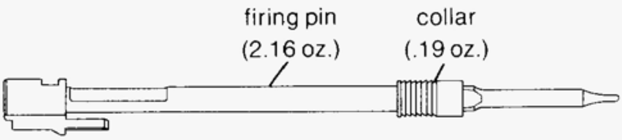
stress at full cock (Wahl corrected)—143,000 lb./sq. in.

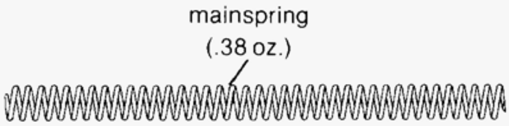
CALCULATED PERFORMANCE

lock time—5.2 ms.

impact velocity—14.2 ft./sec.
energy—102.5 in.-oz.
impulse—1.20 oz.-sec.

Winchester Model 54 Speed Lock





MAINSPRING

free length—5.55 in.

coils—36 total/35 active

ends—ground

wire diameter—.053 in.

outside diameter (free)—.41 in.

rate (computed)—7.1 lb./in.

INSTALLED CONDITIONS

striker fall (to full protrusion)—.26 in.

mainspring compression: at full cock—3.11 in./22.0 lb.
at full striker fall—2.86 in./20.2 lb.

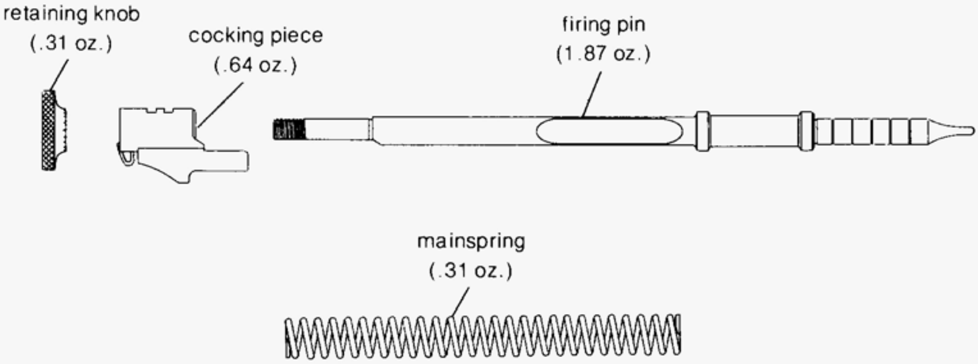
stress at full cock (Wahl corrected)—164,000 lb./sq. in.

CALCULATED PERFORMANCE

lock time—3.1 ms.

impact velocity—12.3 ft./sec.
energy—69.7 in.-oz.
impulse—.95 oz.-sec.

Numrich M1903 Speed Lock


retaining knob
(.31 oz.)
cocking piece
(.64 oz.)
firing pin
(1.87 oz.)
mainspring
(.31 oz.)

MAINSPRING

free length—4.00 in.

coils—28 total/26 active

ends—squared and ground

wire diameter—.053 in.

outside diameter (free)—.41 in.

rate (computed)—10 lb./in.

INSTALLED CONDITIONS

striker fall (to full protrusion)—.29 in.

mainspring compression: at full cock—2.16 in./21.6 lb.
at full striker fall—1.87 in./18.7 lb.

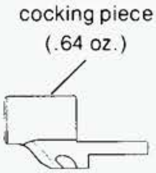
stress at full cock (Wahl corrected)—158,000 lb./sq. in.

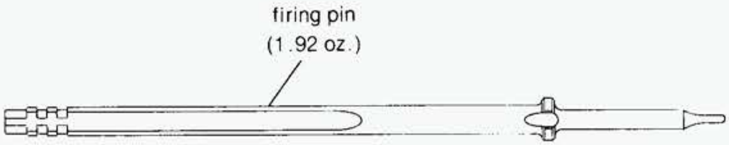
CALCULATED PERFORMANCE

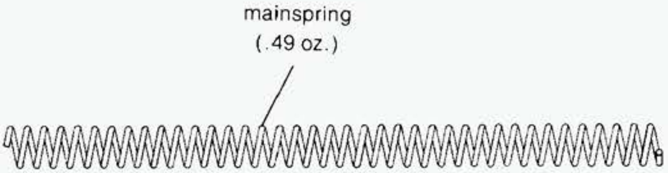
lock time—3.6 ms.

impact velocity—11.6 ft./sec.
energy—73.4 in.-oz.
impulse—1.06 oz.-sec.

Numrich M1917 Speed Lock


cocking piece
(.64 oz.)


firing pin
(1.92 oz.)


mainspring
(.49 oz.)

MAINSPRING

free length—6.92 in.

coils—39 total/39 active

ends—plain

wire diameter—.055 in.

outside diameter (free)—.42 in.

rate (computed)—6.7 lb./in.

INSTALLED CONDITIONS

striker fall (to full protrusion)—.28 in.

mainspring compression: at full cock—3.52 in./23.6 lb.
at full striker fall—3.24 in./21.7 lb.

stress at full cock (Wahl corrected)—163,000 lb./sq. in.

CALCULATED PERFORMANCE

lock time—3.2 ms.

impact velocity—12.4 ft./sec.
energy—77.6 in.-oz.
impulse—1.05 oz.-sec.

THREE-LEVER TRIGGERS

Trigger function is often pictured as simply a series of levers working against spring resistance. In an override trigger adjusted to normal hunting weight (3 to 5 lb.), this is essentially accurate. But when pursuing a very light pull, friction between the working parts emerges as a dominant factor.

For the purposes here, friction within an override trigger can be separated into two categories: Inherent friction and contact-pressure friction. Inherent friction is that existing with the bolt removed, and originates from such things as pivot pins and parts rubbing against the housing walls. Contact-pressure friction is that caused by pressure of the mainspring, and is manifested primarily at the surface where the trigger must slide out from under the sear. In a well-finished trigger, this latter friction should be the controlling factor. It is the subject of this analysis.

Each trigger design has a functional baseline. Even with the poundage spring backed off to just barely reset the trigger (or even removed for that matter) a relatively heavy pull sometimes remains, caused solely by friction. Two solutions to this problem exist. Lapping and polishing all working surfaces to minimize inherent friction is the obvious approach. While this can lead to a useful improvement, performance potential often remains quite limited. To achieve a truly light pull the geometry within the trigger must also be modified to reduce contact forces.

Adding an intermediate lever can diminish contact load between the sear and trigger by a large factor, and since friction can be treated as a direct function of load, it is also reduced a corresponding amount. Three-lever triggers intended for this purpose actually go back many years. Von Martini patented one over a hundred years ago (U.S. Patent 132,222 of Oct. 15, 1872). There have also been many multiple-lever triggers designed for other reasons. Examples are the new Mossberg triggers used in their Model 800 and 810 rifles. Another is the four-lever Winchester Model 52C trigger, where the levers are proportioned primarily to reduce trigger movement, not forces.

To examine specifically the application of a third lever to a production unit, the Remington 700/40X trigger can be used. (Despite a chrome-plated connector and external poundage adjustment, there is little practical difference in performance potential between the Model 700 and the 40X triggers, and thus they can be treated as a common item.)

Table 4 compiles measurements on four of these triggers adjusted for benchrest use. Total poundage at the trigger shoe is separated into spring and friction forces. That listed under the friction column of Table 4 (as well as the remaining tables) actually represents only the contact-pressure portion, since it is the controlling factor. The inherent friction in these particular triggers generally represents only a small fraction of an ounce.

In Table 4, an average of about 1 lb. is caused by friction, thus representing a performance baseline. Even if the poundage spring is removed and discarded, and the mechanism somehow reset manually after each shot, a pull much below 1 lb. is difficult to achieve with this trigger.

Table 4—Remington 700/40X Triggers

No.	Total poundage (oz.)	From spring (oz.)	From friction (oz.)
1	24	4	20
2	20	4	16
3	16	2	14
4	20	4	16

Construction of this trigger is shown in Figure 5. Contact force on the trigger (trigger connector in this case) is just over 6 lb., based on a 24 lb. mainspring. Friction coefficient thus averages a little over .15.

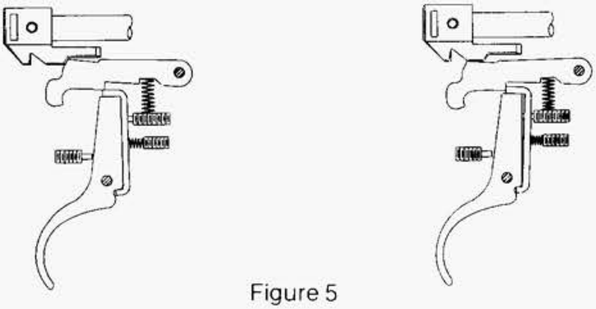


Figure 5

Remington Model 700 trigger

Figure 6 shows the three-lever Remington trigger, which they term the "2-ounce trigger." It is basically a reworked 700 trigger, with a modified sear and trigger piece, an intermediate lever with return spring, a special low-rate poundage spring, and hand-polished working surfaces.

The sear no longer directly loads the trigger connector, and the geometry of the intermediate lever decreases contact force on the trigger by a factor of

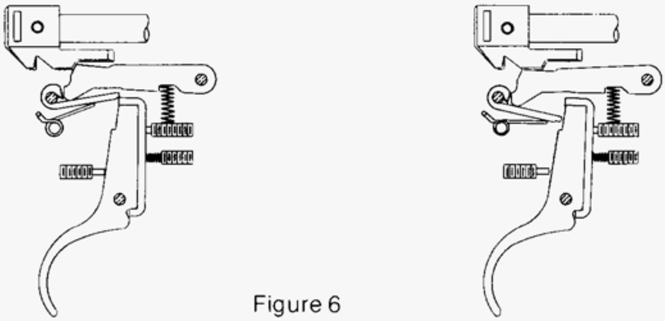


Figure 6

Remington three-lever trigger

almost 6 to 1. Travel, of course, increases a corresponding amount, requiring a special clearance in the rear of the trigger piece. Table 5 analyzes the performance of this trigger.

Table 5—Remington Three-Lever Triggers

No.	Total poundage (oz.)	From spring (oz.)	From friction (oz.)
1	2.5	2.0	.5
2	2.0	1.5	.5

This Remington trigger is set up strictly for ultra-light release, essentially equaling that available in a fine set trigger, and of course without the lock-time penalty of a set trigger. The three-lever principle, however, is equally valid in designing a more general-purpose unit, with poundage in an intermediate range of about 8 to 12 oz.

The M. H. Canjar Co. of Denver, Colorado, makes a more widely used three-lever system. Figure 7 shows the Canjar 700-2S version applied to the Remington Model 700 and 40X. While functionally similar to the Remington 2-ounce trigger, there is one basic difference, and despite a high grade of material and workmanship, it will not tune down to a 2-oz. level. Canjar lists 16 oz. as the lower recommended limit, and recommends addition of their set-trigger shoe for a lighter release.

Table 6 tabulates measurements on two 700-2S triggers regulated to minimum poundage. These are the actual figures required to hold during normal bolt closure, and do not include some large safety factor. For general field work, several more ounces should be added.

While Canjar's third lever does effectively eliminate contact-pressure friction, nevertheless a far heavier poundage spring is required, due to the detailed geometry of the Canjar pattern. In the Remington pattern, the

Table 6—Canjar Three-Lever Triggers

No.	Total poundage (oz.)	From spring (oz.)	From friction (oz.)
1	14	13	1
2	11	10	1

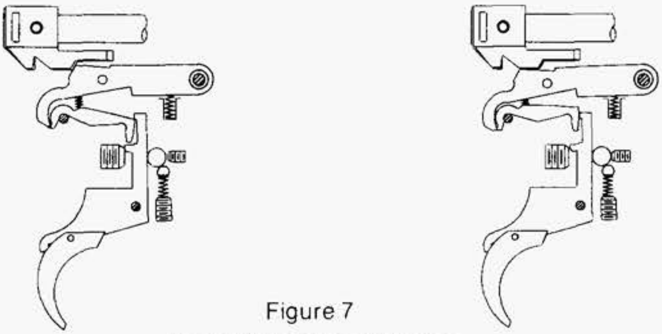


Figure 7

Canjar three-lever trigger

poundage spring need only retract the parts when the bolt is opened between firings. On closing, mainspring pressure transmits down through the exact center of the trigger pivot, creating no component tending to move the trigger either way.

Contact of the Canjar lever, on the other hand, is angled slightly forward, directing the pressure line behind the trigger pivot. A small forward component of mainspring pressure thus exists, which the poundage spring must counteract.

It might seem that this would be no disadvantage, since this forward component also assists when touching off the trigger, exactly counterbalancing the heavier poundage spring needed. This doesn't work out, however, as the spring must be adjusted heavy enough to allow the trigger to *catch* the cocking piece as the bolt closes. Even when carefully closed, the cocking piece drops off the bolt rim, and initial contact with the trigger assembly thus involves some impact effect, well exceeding the steady loading pressure.

Despite this apparent fault, geometry of the 700-2S trigger did not evolve by error. Canjar incorporated the pressure angle because it does allow a cleaner release and is thus preferable in the set-trigger configuration. A couple of prototype 700-2S triggers were modified a few years ago by eliminating the ball bearings and pivoting the parts on trunnions to further eliminate friction, and these will in fact go down to 2 ounces. Because the pressure angle component remains, however, the design is overly sensitive to bolt closure when set that low.

Finally, Karl Kenyon of Ely, Nevada, also makes a highly regarded three-lever system. It is used primarily in small-bore competition and is offered as a factory option on the Winchester Model 52D. The version shown in Figure 8, however, can be applied to Remington centerfire as well as rimfire target rifles. It is an effective combination of design and workmanship. Besides being assembled of precision milled parts, the pattern gives a large leverage ratio to reduce load and friction on the trigger ledge to a very low value as shown in Table 7. Most important, mainspring pressure passes directly through the trigger pin as in the Remington triggers.

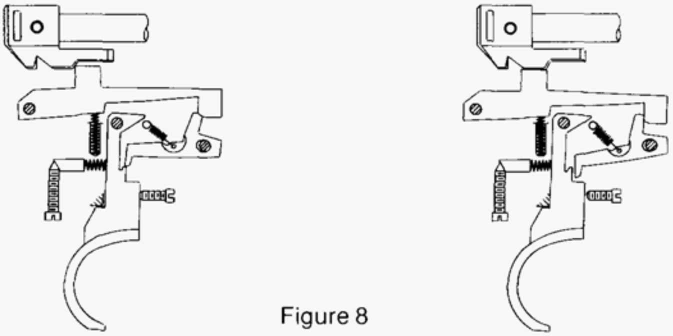


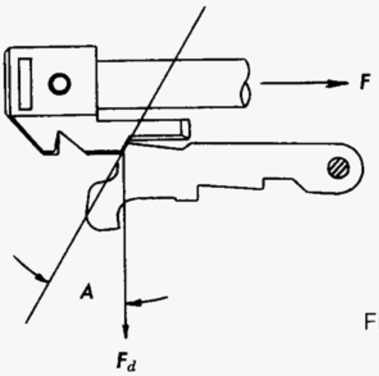
Figure 8

Kenyon three-lever trigger

Table 7—Kenyon Three-Lever Triggers

No.	Total poundage (oz.)	From spring (oz.)	From friction (oz.)
1	5.5	5.0	.5
2	6.0	5.5	.5

Although not shown here, the Kenyon trigger is intended for use with a modified Remington cocking piece where the engagement face is ground back square to reduce contact loads within the trigger. This idea is also occasionally applied to the issue Remington trigger, although here, of course, enough angle must be retained on the two parts to assure that friction at the engagement faces does not impair letoff. An equation giving the net downward component (F_d) can be derived from Figure 9:



$$F_d = F(\cos A \sin A - (\cos A)^2 fo)$$

where: F = mainspring force

fo = coefficient of friction

Figure 9

The net force on the trigger connector itself is less by the ratio of the moment arms from the sear pivot.

BOLT BACK THRUST

Books and magazine articles often refer to the back thrust of a bottleneck cartridge by more or less equating it with chamber pressure. This is inaccurate. Just as important is cartridge diameter, since force is a factor of pressure times effective area. A small-headed cartridge like the .222 Remington and a large one like the .378 Weatherby Magnum may both develop the same chamber pressures, but the potential back thrust effect of the bigger cartridge is obviously much greater.

Also, distribution of back thrust is important and can vary significantly. Rather than being carried entirely by the locking members, it is shared also by the cartridge case structure and the chamber walls. If this weren't so, there would be many very battered-up bolts and receivers around. The bolt directly absorbs the back thrust of the primer. Of the remainder, however, the case and chamber walls absorb a good percentage, depending on the case's rigidity and its grip on the chamber walls.

P. O. Ackley's book *Handbook for Shooters and Reloaders* describes specific tests considering the effect of case design and lubrication, and showing that surprisingly little stress is sometimes transferred to the bolt.

A couple of conclusions can be drawn on locking-lug design, noting, however, that we are not considering a ruptured case head and the affect of uncontained gas. First, cartridge diameter is as important a factor as chamber pressure. Big cartridges create heavy back thrust. Second, the percentage of this stress transferred to the lugs can vary widely. A dry chamber and case puts less strain on the locking system. So does a minimum body-taper case.

Four possible approaches for computing back thrust, each ignoring chamber-wall friction, are considered here:

Approach no. 1:

Chamber pressure acts rearward against the largest inside area of the cartridge base, but also forward against the tapered walls and shoulder area. If the cartridge body itself could control the entire axial component, then net rearward thrust becomes simply pressure times bore area. On this basis, necking down a basic cartridge (from .30-06 to .270 to .25-06, and so on) would progressively relieve strain on the action. Also, the .222 Remington and .22/250 Remington would produce equal back thrust.

Approach no. 2:

The cartridge case, however, can absorb relatively little axial thrust. Thus for computing maximum load it is more valid to simply ignore a forward-acting component. Back thrust then simply equals maximum internal cartridge-base area times chamber pressure.

Approach no. 3:

Assuming the case head separates and the base obturates, then outside case head diameter establishes back-thrust area.

Approach no. 4:

The cartridge rim diameter has occasionally been taken as a basis for figuring back thrust. A little thought eliminates this as a valid assumption. Simply adding an enlarged rim to the .30-06 cartridge head, for example, obviously would not modify back thrust. Further, by this theory, the .30-30 Winchester has considerably more back-thrust area than the .30-06.

Table 8 lists the maximum back thrust computed for a .30-06 cartridge at 50,000 lb./sq. in. chamber pressure with each approach:

Table 8

Approach	Back thrust diameter (in.)	Back thrust area (sq. in.)	Back thrust (lb.)
1	.308	.075	3,725
2	.400	.126	6,300
3 & 4	.473	.176	8,800

The second approach is obviously the most valid. Table 9 lists computed back-thrust levels at a chamber pressure of 50,000 lb./sq. in. for several modern centerfire cartridges based on this approach. Since these computations ignore both chamber wall friction and the structural integrity of the cartridge walls, they are certainly maximum based on a static analysis. More involved analysis is possible, however, which considers transient effects and gives even higher values under some conditions.

Table 9

Cartridge	Type	Head diameter (in.)	Rim diameter (in.)	Max. inside case diameter (in.)	Max. back thrust area (sq. in.)	Max. back thrust (lb.)
.222 Remington	rimless	.376	.376	.320	.080	4,025
.224 Weatherby	belted	.415	.429	.355	.099	4,950
.225 Winchester	semi-rimmed	.422	.473	.365	.105	5,225
.240 Weatherby	belted	.450	.470	.390	.119	5,975
.30–06 Springfield	rimless	.473	.473	.400	.126	6,300
.284 Winchester	rebated-rimless	.497	.473	.440	.152	7,600
.375 H&H	belted	.510	.527	.445	.156	7,775
.378 Weatherby	rebated-belted	.587	.605	.515	.208	10,425

CARTRIDGE LENGTHS

To put magazine and loading/ejection port dimensions in perspective, Table 10 is a tabulation of typical cartridge dimensions. The overall lengths are from SAAMI standards, and as can be seen, tend to fall into a few more or less distinct groups.

Table 10

Cartridge	Case length (in.)	Max. overall cartridge length (in.)	Case-head diameter (in.)	Primer diameter (in.)
.222 Rem.	1.70	2.13	.376	.175
.222 Rem. Mag.	1.85	2.28	.376	.175
.22–250 Rem.	1.91	2.35	.473	.210
.243 Win.	2.05	2.71	.473	.210
6mm Rem.	2.23	2.83	.473	.210
.250 Sav.	1.91	2.52	.473	.210
6.5 Rem. Mag.	2.17	2.80	.532	.210
.308 Win.	2.02	2.80	.473	.210
.264 Win. Mag.	2.50	3.34	.532	.210
.270 Win.	2.54	3.34	.473	.210
7mm Rem. Mag.	2.50	3.29	.532	.210
.30–06 Sprg.	2.49	3.34	.473	.210
.300 Win. Mag.	2.62	3.34	.532	.210
.338 Win. Mag.	2.50	3.34	.532	.210
.458 Win. Mag.	2.50	3.34	.532	.210
.300 H&H Mag.	2.85	3.60	.532	.210
.375 H&H Mag.	2.85	3.60	.532	.210

FIRING PIN PROTRUSION

Insufficient firing pin protrusion causes misfires and excessive protrusion causes pierced primers. Both are widely accepted principles. A detailed examination of firing pin impact, however, justifies some refinement and modification of these assumptions.

Firing pin protrusion is the distance the striker tip can travel beyond the bolt face when *dry-fired*, and is normally between .055 and .085 in. It is controlled by stop surfaces built into the bolt and firing unit, usually either the cocking piece head in combination with an interior shoulder in the bolt sleeve (e.g., the Mauser M98) or up front the mainspring flange impacting into a shoulder in the bolt head (e.g., the Remington Model 700). Very seldom are the cocking cams involved, although an exception is the Texas Magnum which utilizes its massive three-lobed cocking-cam system for this purpose.

First, considering misfires, what penetration is required for reliable ignition? If one tests a variety of bolt actions and ammunition it will be found that primer indentation seldom exceeds about .020 in. (SAAMI documents specify .018 to .026 in.). Of course protrusion must exceed this somewhat to allow for tolerances and linear compression within the system. Nevertheless, a .045 in. protrusion is more than sufficient unless something in either the rifle or ammunition is way out of tolerance.

What then causes misfires, apart from bad primers? Most often they result from a cushioned impact, either from a partially seated primer or a cartridge too short for the chamber. An inherently spongy firing pin, as in the Springfield M1903, doesn't help matters, nor does a shallow-shoulder cartridge profile. Insufficient energy is another likely cause, and can result from a weakened or set mainspring, a binding firing pin, the effect of low temperature on grease or oil within the bolt, or an insufficient striker fall. An off-center blow to the primer also weakens impact and requires extra energy to compensate.

Pierced primers can be analyzed in the same manner. Excessive protrusion, in itself, cannot pierce primers. In fact, protrusion control doesn't even enter into the normal firing process. Since primer indentation is only around .020 in., whether the protrusion-control surfaces would have contacted at .060, .080, or even .100 in., is academic. If the striker point does penetrate deep enough for these shoulders within the action to act, the primer is already in trouble.

The primary causes of pierced primers are improperly shaped striker tips and thin primer cups. Blanked primers, which for practical purposes lead to the same result, are actually a much more common, although less frequently mentioned, problem. These are caused again by thin primer cups, but also by overpressure, oversize firing pin holes, and weak mainsprings. These last two cause a loss of the support which the firing pin must provide the primer cup against pressure. In fact, in some light-weight inertia type firing systems, blanked and partially blanked primers are regular occurrences.

Based on the above, why control excess protrusion? The primary reason for close control is to regulate delivered energy. As illustrated in the Sako chapter, excessive protrusion cuts down firing pin fall, and in the process can significantly degrade the impact delivered to the primer.

PATENT SUMMARY

Below is a chapter-by-chapter summary of the patents referenced in this book. Since the publication of the first edition, I have analyzed a number of these patents for *Rifle* Magazine (Wolfe Publishing Co., Prescott, Arizona) in my "Rifle Patents" column. Therefore this tabulation includes a reference to the issues of the magazine in which the patent analyses have appeared.

Chapter	Page	Patent No.	Issue number and date of Rifle Magazine analysis
1 Mauser Model 98	1, 21	78,603	72 (November, 1980)
	2	427,587	65 (September, 1979)
	2, 19	431,668	—
	2	431,669	65 (September, 1979)
	2	431,670	65 (September, 1979)
	2, 17	440,955	—
	2	449,352	—
	13	467,180	66 (November, 1979)
	12	476,290	66 (November, 1979)
	13	477,671	66 (November, 1979)
	21	488,694	—
	20	496,691	—
	20	499,328	—
	14	527,869	—
	18	547,933	77 (September, 1981)
	6, 7	579,994	63 (May, 1979)
	15, 17, 20	590,271	72, 74 (November, 1980; March, 1981)
	8	56,068 (German)	—
	7	89,815 (German)	—
	15	120,477 (Belgium)	—
	22	154,915 (German)	—
2 Springfield M1903	41	1,780,521	—
	34	3,444,641	—
4 U.S. Enfield M1917	71	2,373,141	—
6 Winchester Model 54	90	1,322,242	78 (November, 1981)
	85	1,355,673	—
	89	1,566,877	78 (November, 1981)
	88	1,631,242	78 (November, 1981)
	91	1,780,521	—
	89	2,099,035	79 (June, 1982)
7 Pre-'64 Winchester Model 70	105	90,614	—
	106	223,662	—
	101	1,225,640	—
	106	1,741,281	62 (March, 1979)
	102	1,898,670	79 (January, 1982)
9 Remington Models 721/722, 725 and 700	132	2,191,521	—
	130	2,341,299	64 (July, 1979)
	120	2,383,356	—
	127	2,473,373	—
	129	2,514,981	64 (July, 1979)
	122	2,585,195	63 (May, 1979)
10 Weatherby Mark V/Mark V Varmintmaster	151	2,191,521	—
	151	2,514,981	64 (July, 1979)
	141	3,013,355	72 (November, 1980)
	141, 151	3,024,559	77 (September, 1981)
11 Sako L-461 Vixen	169	431,670	65 (September, 1979)
	171	440,955	—
13 Mossberg Model 800	188	2,101,236	—
	—	3,234,679	77 (September, 1981)
14 Remington Model 788	198	579,994	63 (May, 1979)
	198	2,585,195	63 (May, 1979)
15 Winchester Model 70 (1968 Version)	220	431,669	65 (September, 1979)
	220	3,431,668	59 (September, 1978)
Appendix, Lock Time	256	3,056,226	76 (July, 1981)
Appendix, Three-Lever Triggers	270	132,222	—

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